LIST OF THE OFFICERS

OF

The Institution of Petroleum Technologists,

1931-1932.

Past Presidents:

*Sir Boverton Redwood, Bart., D.Sc., F.R.S.E. (1914-1916).
Prof. Sir John Cadman, G.C.M.G., D.Sc., M.Inst.C.E., M.Inst.M.M. (1916-
The Rt. Hon. Lord Greenway of Stanbridge Earls (1917-1919). [1917).
*Sir Frederick W. Black, K.C.B., B.A. (Lond.) (1919-1921).
Prof. John Samuel Strafford Brame, C.B.E., F.I.C., F.C.S. (1921-1923).
Herbert Barringer, M.Inst.C.E., M.I.Mech.E., M.I.N.A., M.Inst.Mar.Eng.
(1923-1925).
Sir Thomas H. Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S. (1925-1927).
Alfred C. Adams (1927-1929).
A. E. Dunstan, D.Sc., F.I.C., F.C.S. (1929-1931).

President:

James Kewley, M.A., F.I.C., F.C.S.

Vice-Presidents:

Sir John T. Cargill, Bart., Hon. LL.D.
A. E. Chambers, A.M.Inst.C.E.
T. Dewhurst, A.R.C.Sc., F.G.S.
Alexander Duckham, F.C.S.
Arthur W. Eastlake, M.I.Min.E., A.M.I.Mech.E.
A. Beeby Thompson, O.B.E., M.I.Mech.E., M.Inst.M.M., F.G.S.

Members of Council:

Ashley Carter, A.M.I.Mech.E.
G. H. Coxon.
A. Frank Dabell, M.I.Mech.E.
C. Dalley, M.I.E.E.
B. J. Ellis.
F. H. Garner, Ph.D., M.Sc., F.I.C.
T. R. H. Garrett, M.A., F.G.S.
John Gillespie, M.I.Mech.E.
Prof. V. C. Illing.
J. S. Jackson, B.Sc., A.I.C.
Prof. A. W. Nash, M.Sc., F.C.S., M.I.Mech.E.
J. McConnell Sanders, F.I.C., F.C.S.
William Sutton, M.I.Min.E.
F. B. Thole, D.Sc., F.I.C., F.C.S.
A. Wade, D.Sc., A.R.C.S., F.G.S., M.Inst.M.M., F.Am.G.S.

Honorary Treasurer: Lord Plender of Sundridge, G.B.E
Solicitors: Messrs. Ashurst, Morris, Crisp & Co.
Auditors: Messrs. Price Waterhouse & Co.

* Deceased.

Bankers:
WESTMINSTER BANK, LIMITED.
21, Lombard Street, London, E.C. 3.

Hon. Editor:
A. E. DUNSTAN, D.Sc., F.I.C., F.C.S.

Associate Editor and Secretary, Standardisation Committee:
GEORGE SELL.

Hon. Secretary:
ARTHUR W. EASTLAKE, M.I.Min.E., A.M.I.Mech.E.

Secretary:
Commander R. E. STOKES-REES, R.N.

Librarian:
Miss CLARE DESPARD.

Offices—Aldine House, Bedford Street, Strand, London, W.C. 2.
Telegrams: Instpetech, Westrand, London.
Telephone: Temple Bar 1842.

CONTENTS.

	PAGE
Council and Officers	i-ii
General Notices	v-vii
Personal Notes and Special Notices	vii-ix
Note on the Specific Heat of some Crude Oils and their Residues when topped to 100° C. By H. R. LANG, Ph.D., F.Inst. P.	585
The Chemical Aspect of Drilling Muds. By ALEXANDER DUCKHAM, F.C.S. Discussion	592
Behaviour of Restricted Wells. Discussion	611
The Removal of Weak Organic Acids from Oils by Treatment with Caustic Alkali. By P. MEYER, B.Sc., A.I.C.	621
Current Petroleum Notes	629
Review	630

ABSTRACTS

	PAGE		PAGE
Geology	455A	Special Products	471A
Field Technology	458A	Refining and Refinery Plant.	473A
Crude Oil	460A	Cracking	476A
Gas	461A	Hydrogenation	481A
Motor Fuels	463A	Chemistry of Petroleum ..	481A
Lubricants and Wax ..	465A	Analysis and Testing ..	484A
Fuel Oil	470A	Anti-Detonation	487A
Fluxes and Asphalts.. ..	471A	Engines	492A

AUTHOR INDEX.

The numbers refer to the Abstract Number.

Apgar, F. A., 1200
Ariel Works, Ltd., 1179
Atlantic Refining Co., 1199, 1206
Automotive Distillate Corporation, 1215

Babcock & Wilcox, Ltd., 1186
Barford, V. G., 1254
Barnard, D. P., 1176
Bignell, L. G. E., 1147
Binnie, D., 1232
Birkhimer, E. R., 1173
Black, J. C., 1212, 1221
Boyd, T. A., 1243
Bozer, M. C., 1230
Bridgeman, O. C., 1166
Bright, R. T., 1159
Brooks, D. B., 1240
Butler, 1223

Campbell, J. M., 1243
Chemische Fabrik Kulk G.m.b.H., 1193
Cope, J. Q., 1233
Cowles, H. C., 1205
Cross, R., 1222, 1228
Cross, W. M., 1226
Cross Dev. Corpn., 1222

Damm, P., 1206
Darlington, H. T., 1217
Dearborn, R. J., 1220
Dennis Bros., 1251
Detonation Sub-Committee, 1247
Dunstan A. E., 1231

Edgar, G., 1241
Egloff, G., 1160
Evans, E. V., 1237

Fairweather, H. G. C., 1199
Ferris, S. W., 1173, 1180
Fisher, A., 1162
Ford, J. G., 1182
Ford, L. R., 1249
Francis, W., 1163
Frankish, A., 1186
Funsteig, R., 1210

Gaddess, J., 1154
Gainer, F. J., 1209
Gasoline Products Co., 1221
Glasgow, J. G., 1207
Goodwin, R. T., 1196
Gordon, D., 1155
Gray, G. W., 1220
Groote, M. de, 1161
Gulf Refining Co., 1208
Gyro Process Co., 1225

Hague, E. N., 1231
Hancock, W. T., 1219
Harnsberger, A. E., 1224
Henderson, L. M., 1173, 1205
Hesselman, K. J. E., 1252
Hill, J. B., 1244
Hudnall, J. S., 1148, 1149
Huff, H. F., 1244

I. G. Farbenind, A.-G., 1170, 1192, 1194
Imperial Chemical Industries, 1163

Jenkins, U. S., 1218
Jenkins Petroleum Process Co., 1218
Johnson, J. Y., 1192

Keiser, E. H., 1161
King, R. O., 1248
Koppers Co., 1206
Kremer, M., 1167
Kuhl, P. E., 1165

Lacey, W. N., 1239
Lane, R. S., 1202
Lewis, W. K., 1233
Logan, J., 1150
Loomis, N. E., 1216
Lovell, W. G., 1243
Lowery, H., 1202
Lyman, A. L., 1184

MacCoull, N., 1245, 1246
Mailhe, A., 1190
Marek, L. F., 1234
Maxwell, R. G., 1146
McCluer, W. B., 1234
Monson, L. T., 1161
Moss, H., 1248

Nelson, E. F., 1160
Nichols, H. J., 1165

Oak, P. T., 1176
Ochne, H., 1193
Osterstrom, R. C., 1213

Packard Motor Car Co., 1253
Park, J. A., 1189
Peters, G. D. & Co., 1178
Pickard, H., 1237
Pierce, D. E., 1206
Pöll, H., 1236
Poppe, P. A., 1251
Prutzman, P. W., 1183

Rabl, A., 1172
Renaudie, —, 1190
Rial, W. D., 1181
Richfield Oil Co., 1198
Rodgers, G. C., 1240
Rosenstein, L., 1169
Ross, C. A., 1166
Ross, J. S., 1157
Russell, R. P., 1230

Sabins, J. R., 1244
Sangster, J. Y., 1179
Schaarschmidt, A., 1235
Sclater, K. C., 1158
Shiffler, W. H., 1227
Sinclair Refining Co., 1200
Smith, H. G., 1203
Smith, J. E., 1153
Soc. d'Etudes et Realisation dite "Ereal," 1195
Soc. Indus. des Hydrocarbures et Derives, 1664
Spielmann, P. E., 1187
Stacey, H. R., 1242
Standard Oil Co. (California), 1184, 1227
Standard Oil Co. (Ind.), 1202, 1209
Standard Oil Dev. Co., 1165, 1177, 1196, 1229, 1230
Stratford, C. W., 1201, 1204
Sullivan, R. W., 1176
Swindell, F., 1151

Tatum, J. L., 1152
Tausz, J., 1172
Texas Co., 1214, 1220
Thornycroft, J. I. & Co., 1254
Tizard, H. T., 1250
Toennies, G., 1238
Tretolite Co., 1161
Triggs, W. W., 1196
Truesdell, P., 1160

Versluys, J., 1145
Voorhees, V., 1176

Wade, H. C., 1211
Walther, C., 1171
Wagner, C. R., 1213, 1225
Watson, C. B., 1224
Weaver, J. B., 1225
Weber, H. C., 1233
Westinghouse Electric Co., 1182
Wheeler, R. V., 1231
Wheeler, T. S., 1163
White, A. E., 1214
White, H. S., 1166
White, N. R., 1240
Wilhelmi, R., 1188

Young, H. A., 1174

SYMPOSIUM ON SALT DOMES.

A few copies of the complete Symposium on Salt Domes, including the discussion and the geophysical papers, in one complete volume are available at 10s. 6d. each.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS

NOTICES.

The Institution as a body is not responsible for the statements of opinion expressed in any of its publications.

Copyright. Authors of papers and articles are requested to transfer their copyright to the Institution for a period of six months from the date of receipt of the paper. Such transfer should be made in writing when the manuscript is forwarded to the Editor.

Editors are permitted to publish abstracts, providing that acknowledgment is made to The Institution of Petroleum Technologists.

Issue of Journal. The Journal is issued in twelve parts per volume, commencing in January of each year. The Title Page, Table of Contents and Index to each volume are published in the second issue of the succeeding volume.

Members whose subscription is not in arrear receive the Journal free of cost, and additional copies are charged at the rate of 7s. 6d. per part, unless otherwise stated. A member whose subscription is not paid by March 31st of the year for which it is due is considered to be in arrear.

Changes of Address. Members are requested to notify any change of address to the Secretary.

Papers and Articles. Members are invited to submit papers to be read at the General Meetings of the Institution, and are specially asked to forward articles for consideration for publication in the Journal. Diagrams, illustrations, etc., should be suitable for direct photographic reproduction. Authors are informed that all papers, whether for reading or for publication, will be submitted to a referee nominated by the Publication Committee.

Authors of papers published in the Journal are entitled to receive 25 free reprints of their contribution. Further copies may be obtained on payment, and orders for these should be sent to the Secretary when the manuscript is forwarded to the Editor. The free reprints do not include any discussion which may be published with the paper, but authors may have such discussion included in their reprints on payment of the additional cost.

Galley proofs of the paper to be read at a General Meeting are available at the time of the meeting, but members desirous of receiving such galley proofs in advance should apply to the Secretary.

Binding of Journals. Members desiring to have their Journals bound in cases should send them, together with a remittance of 5s. 6d. per volume, to Messrs. Speaight & Sons, Ltd., 98, Fetter Lane, London, E.C. 4. A charge of 7s. 6d. will be made for binding Vol. 10, 1924. Remittance in all cases must accompany the order.

Abstracts. Abstracts of the more important articles and patent specifications are published with each issue of the Journal, this supplement being paged independently of the transactions. Members desiring to have the Abstracts printed on one side of the paper only can be supplied with these at a charge of 10s. per annum per copy, payable in advance.

Medals. The Redwood Medal is awarded, at the discretion of the Council, to the person who shall have made the most meritorious contribution to petroleum technology, in the form of a paper or papers published in the Journal of the Institution, during two successive sessions, preference being given to original work and to papers which have been read before the Institution and discussed. The award is not confined to members of the Institution and may be withheld if no contribution is considered to be of sufficient merit.

A medal and a prize of five guineas is awarded annually by the Council to that Student Member of the Institution who shall, in their opinion, have presented the best paper during the session.

Benevolent Fund. The Benevolent Fund is intended to aid necessitous persons who are or have been members of the Institution, and their dependent relatives.

The Fund is raised by voluntary annual subscriptions, donations, and bequests, and all contributions should be sent to the Secretary of the Institution at Aldine House, Bedford Street, London, W.C. 2. The Fund is administered by the Council through the Benevolent Fund Committee, and all applications in connection therewith must be made on a special form which can be obtained from the Secretary of the Institution.

Appointments Register. A register of members requiring appointments is kept at the office of the Institution for the convenience of firms requiring the services of petroleum technologists, etc., it being understood that the Institution accepts no responsibility and gives no guarantee.

Library. The Institution's Library may be consulted between the hours of 11 a.m. and 4 p.m. daily. (Saturdays, 11 a.m. to 12 noon.)

Advertisements. Advertisements are inserted in the Journal, and information as to terms, etc., can be obtained from Mr. Thomas Tofts, 301-302, Bank Chambers, 329, High Holborn, W.C. 1. (Telephone No. Hol. 4776.)

LIST OF ADVERTISERS.

Members are desired when making enquiries or placing orders with advertisers to mention that they have seen their announcement in the Journal.

ANGLO-AMERICAN OIL CO., LTD.

W. CHRISTIE & GREY, LTD.

A. F. CRAIG & CO., LTD.

FOSTER WHEELER, LTD.

W. J. FRASER & CO., LTD.

HADFIELDS LTD.

HAYWARD-TYLER & CO., LTD.

NATIONAL SUPPLY CORPORATION.

JOHN G. STEIN & CO., LTD.

STEWARTS & LLOYDS, LTD.

SULLIVAN MACHINERY CO. (INC.)

J. WALMSLEY.

ALFRED WIRTH & CO.

PERSONAL NOTES OF MEMBERS AND SPECIAL NOTICES.

It is suggested that members send information regarding their movements to the Secretary, for insertion under this heading.

We tender our congratulations to Mr. T. J. C. Burgess on his being promoted to the rank of Officer of the Legion d'Honneur by the French Government.

Mr. R. ALLAN has returned from Venezuela.

Mr. W. E. AYLWIN is home from Persia.

Mr. R. G. FROULKES-JONES has returned from Trinidad.

Mr. A. J. GOODMAN is home from Canada.

Mr. G. W. LEPPER has returned to Burma.

Mr. A. PARKHIDEH has left for Persia.

Mr. C. ROSS has left for Burma.

Mr. C. A. H. WILLIAMS is home from Venezuela.

Mr. Y. P. WILSON has returned to Iraq.

The Secretary would be glad to hear of the whereabouts of the following members: C. A. BAUDUIN, N. M. BRODIE, E. H. CRUSH, B. DVORKOVITZ, P. M. FALCONER, R. E. FITZ-SYMONS-BAMPTON, L. B. HOLLOWAY, C. E. JOBLING, H. LESLIE LITTLE, E. MOSCOVICI, F. A. I. MUNTZ, NAND LAL PASI, R. E. PALMER, E. COOPER SCOTT, W. E. SHEPHERD, DAVID STEEL, C. M. STONEY, L. J. TRUSS, R. K. VAN SICKLE, F. E. G. WATSON and S. S. WEBB-BOWEN.

DINNER CLUB.

The attention of members is drawn to the Dinner Club of the Institution. This Club holds informal dinners after each General Meeting of the Institution and members may invite guests. Those desiring to receive notice of these dinners are requested to inform the Secretary of the Institution.

SMALL ADVERTISEMENTS.

In future the advertisement columns of the Journal will be open for the inclusion of small prepaid advertisements, such as Situations Vacant and Wanted, Patents for Sale and Miscellaneous, at a charge of 1s. 0d. per line of seven words (minimum 4s. 0d.). A charge of 1s. 0d. will be made for the use of a box number. Matter for insertion should be in the hands of the Associate Editor not later than the 12th of the month in which it is desired that the advertisement should appear.

OBITUARY.

ROBERT REDWOOD, F.C.S., M.Inst.P.T.

We deeply regret to record the death of Mr. Robert Redwood on September 24th last at the age of 75. Mr. Redwood was born in London and was one of the younger of six sons of Dr. Theophilus Redwood, who for forty years was Professor of Pharmacy at the Pharmaceutical Society, London.

His connection with the Petroleum Industry dates from the earliest days of the importation into this country of Petroleum from America. In association with his brother, the late Sir Boverton Redwood, Bart., he occupied the position of Secretary to the Petroleum Defence Committee, which was formed to protect the interests of the new Industry created by the introduction of "Case Oil" and Petroleum in barrels.

He was an active Member of the Petroleum Association from its earliest days, and on the introduction of bulk shipments into this country he made a special study of all details connected with the conveyance and transport of the various Petroleum Products. This was carried on in collaboration with his brother until the death of the latter in 1919.

Mr. Redwood was Adviser under the Petroleum Acts to the Corporation of the City of London, and his advice on the storage of Petroleum Products was constantly sought by companies throughout the country.

His connection with the motor car industry dates from the introduction of motor cars into this country, and he was a Founder Member of the Royal Automobile Club. He had, therefore, been an observer of the tremendous strides which this industry has made over quite a short period of time.

Mr. Redwood was a Founder Member of our Institution and a Vice-President. His interest in the progress of the Institution was very keen, and his advice was constantly sought, and readily given, in the Council and its Committees of which he was a member. His work on the Standardization Committee was invaluable, and he gave himself unsparingly to promote the interests of the Technology of Petroleum and to place it on a sound and useful basis. We shall miss his wise and kindly counsel in the details of organisation connected with the Institution.

The chief recreations of Mr. Redwood were shooting and golf. He was a Founder Member of the Felixstowe Golf Club, and continued a keen follower of this game until increasing years prevented active participation in it.

Mr. Redwood was the Senior Partner in the firm of B. & R. Redwood, and maintained to the last an active interest in all matters connected with his profession. He was a man of unassuming disposition and rare charm.

We extend to the relatives of Mr. Redwood our real sympathy in their loss.

A. W. C.

STANDARD METHODS OF TESTING PETROLEUM AND ITS PRODUCTS.

SECOND EDITION.

Giving full details of revised and new Methods of Test of Petroleum and Its Products.

Price: **7s. 6d.** net.

To members of the Institution, marked "Member's Copy," 5s. net.
(Limited to one copy per member.)

DECENNIAL INDEX, 1914 to 1924.

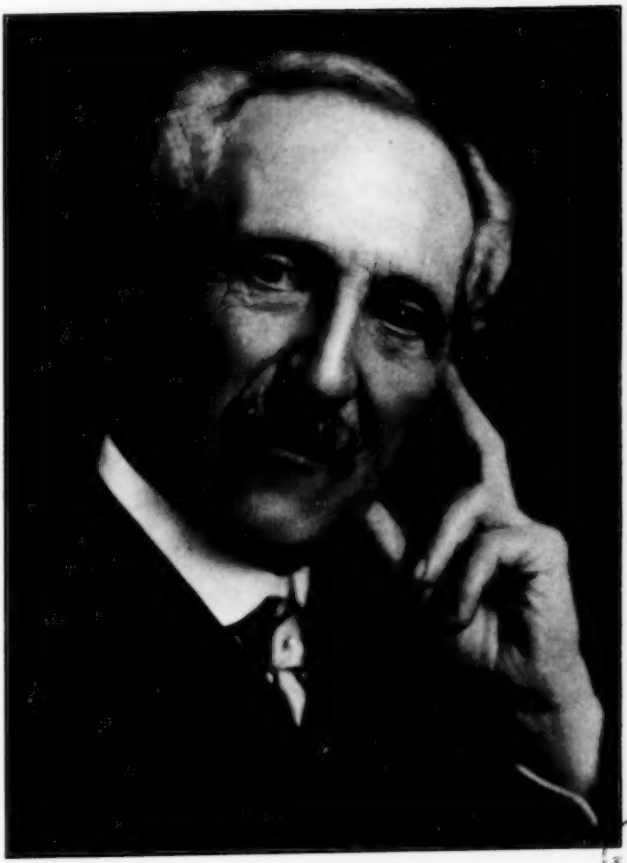
The complete index to the first ten volumes of the Journal of the Institution contains some 10,000 references to subjects and localities.

Price: **7s. 6d.** net.

To members of the Institution. 4s. net.

All the above to be obtained from the office of the Institution,

ALDINE HOUSE, BEDFORD STREET, STRAND, LONDON, W.C. 2.



ROBERT REDWOOD,

F.C.S., M.Inst.P.T.

UNIV. OF MICH.

Note on the Specific Heat of some Crude Oils, and their Residues when Topped to 100° C.*

By H. R. Lang, Ph.D., F.Inst.P., Research Fellow, Institution of Petroleum Technologists.

1. *Introduction.*—It was stated at the end of a paper recently published in this journal[1] that a further discussion of the results would be given when more detailed analyses of the samples were available. These have now been completed at the Central Laboratories of the Shell Marketing Company, to whom grateful thanks are due for their kindness in arranging for this work to be carried out. The samples that have been analysed were not in every case those on which the calorimetric measurements were made, but when this was not so they had been drawn from the same barrel, and are not therefore likely to be much different. Sufficient data are given to fairly define the oils used in the experiments.

2. *The Analyses.*—Tables I., II., and III. give a summary of the report (No. 5618/30) on the analyses made. Unfortunately a sample of the untopped Pennsylvanian oil was not available for analysis. In Table I. the specific gravity found in our experiments, and corrected to 15° C./4° C., is shown alongside those found by the analysts, and the values given are those at the beginning and end of each series of experiments. The agreement between our figures and those found at the Central Laboratories is satisfactory.

* Paper received May 15th, 1931.

[1] Lang and Jessel, *J. Inst. Petr. Techn.*, 1930, **16**, 476.

TABLE I.

Sample.	Specific Gravity at 15° C./4° C. (1). Shell.	Lang & Jessel.	Viscosity. Red. I. (32) at 70° F. secs.	100° F. secs.	Absolute (79) at 70° F. centipoises.	100° F. centipoises.	Acid Value (26) equivalent to mgm.KOH/1 gm. oil.
Pennsylvanian Crude Oil, topped to 100° C.	0.856	0.852–0.854	62	46	10.5	6.2	0.24
Pennsylvanian Crude Oil, untopped ..	—	0.838–0.838	—	—	—	—	—
Californian Crude Oil (I.B.P. over 100° C.)	0.934	0.930–0.932	361	147	83.2	33.8	1.4
Mid-Continent Crude Oil, topped to 100° C.	0.838	0.836–0.837	61	45	9.4	5.6	0.10
Mid-Continent Crude Oil, untopped ..	0.826	0.823–0.830	45	38	5.8	3.8	0.10
Persian Crude Oil, untopped	0.848	0.845–0.850	43	37	5.3	3.5	0.10
Persian Crude Oil, topped to 100° C. ..	0.870	0.867–0.868	63	46	11.5	6.7	0.27

TABLE II.

	Pennsylvanian Crude (Topped).	Californian Crude.	Mid-Continent Crude. (Topped).	(Untopped).	Persian Crude. (Topped).	(Untopped).
I.P.T. Distillation :—						
Barometric Pressure, mm.	758	757	758	758	757	757
I.B.P., ° C.	139	138	133	72	134	62
To 150° C. % vol.	2	1	3.5	15.5	5.0	19.5
To 300° C. % vol.	50	35	47.5	52.5	47.5	55.5
Sp. Gr. at 15° C./4° C. of fraction to 150° C. ..	—	—	—	0.727	—	0.720
Sp. Gr. at 15° C./4° C. of fraction 150° to 300° C.	0.800	0.860	0.794	0.794	0.810	0.808
Residue at 300° C. % vol.	49	64	51.6	47.0	52.0	44
Sp. Gr. (48) at 15° C./4° C.	0.907	0.970	0.879	0.878	0.926	0.927
Conradson Carbon Residue (12) %wt. ..	4.45	6.5	1.34	1.22	5.2	4.62
Asphaltenes :—						
Insol. in Alcohol Ether %wt.	2.6	2.0	0.97	0.77	4.0	4.2
Insol. in Sulph. 60/80 Petr. Spirit (17) %wt.	0.58	0.49	Negligible	Negligible	0.38	0.39

TABLE III.

B.P.M. DISTILLATION OF THE UNTOPPED OILS.

Mid-Continent Crude Untopped.

Specific gravity at 15° C./4° C. (1)—0.826.

B.P.M. Distillation.—(Cut at 193° C. for 200° C. actual to give benzine of final boiling point 200° C.)

Charge in still = 1,000 ccs. at 15° C. = 826 grams.

Fraction.	Per-centage Weight.	Per-centage Volume.	Specific Gravity of Fraction at 15/4° C.	Vapour Tempera-ture. ° C.	Still Tempera-ture. ° C.
Distillation Commenced	—	—	—	35	147
1	1.71	2.10	0.673	75	163
2	3.50	4.19	0.708	94	174
3	5.36	6.31	0.725	104	183
4	7.20	8.38	0.733	113	192
5	9.07	10.46	0.740	121	200
6	11.04	12.64	0.747	132	211
7	12.95	14.73	0.754	141	218
8	14.87	16.82	0.760	152	228
9	16.80	18.90	0.766	161	236
10	18.75	21.00	0.770	169	244
11	20.71	23.09	0.774	177	252
12	22.71	25.22	0.778	187	262
13	24.15	26.74	0.780	193	269

Distilling to 200° C. (193° C. apparent), 24.1% wt. ; 26.7% vol.

Unrefined Benzine.

Specific Gravity at 15° C./4° C. (1)	0.750
Distillation A.S.T.M. (4)	759 mms.
Initial boiling point	72° C.
2% vol recovered at	87.5 (approx.)
5 „ „	95 „
10 „ „	102
20 „ „	111
30 „ „	119.5
40 „ „	127
50 „ „	136.5
60 „ „	145.5
70 „ „	154.5
80 „ „	165
90 „ „	178
Final boiling point	204
Recovery at 100° C.	8.5% vol.
Recovery at 140° C.	54% „
Total recovery	98.5% „

Persian Crude (Untopped).

Specific gravity at 15° C./4° C. (1)—0.848.

B.P.M. Distillation.—(Cut at 193° C. for 200° C. actual to give benzine of final boiling point, 200° C.).

Charge in still = 1,000 ccs. at 15° C. = 848 grams.

Fraction.	Percentage Weight.	Percentage Volume.	Specific Gravity of Fraction at 15/4° C.	Vapour Temperature. ° C.	Still Temperature. ° C.
Distillation Commenced	—	—	—	29	123
1	1·66	2·15	0·652	64	138
2	3·38	4·27	0·690	79	151
3	5·17	6·41	0·706	90	160
4	6·96	8·53	0·720	99	170
5	8·79	10·65	0·730	107	179
6	10·64	12·77	0·739	116	189
7	12·54	14·93	0·747	126	200
8	14·46	17·10	0·754	134	207
9	16·45	19·31	0·761	142	216
10	18·48	21·56	0·768	152	227
11	20·54	23·81	0·773	161	237
12	22·55	26·02	0·778	168	245
13	24·60	28·23	0·782	179	256
14	26·60	30·38	0·787	188	266
15	27·97	31·85	0·790	193	272

Distilling to 200° C. (193° C. apparent), 28·0% wt.; 31·8% vol.

Unrefined Benzine.

Specific gravity at 15° C./4° C. (1)	0·749
Distillation A.S.T.M. (4)	759 mms.
Initial boiling point	61° C.
2% vol. recovered at	75 (approx.)
5 „ „	83·5 (approx.)
10 „ „	91·5
20 „ „	102
30 „ „	112
40 „ „	122
50 „ „	132
60 „ „	141
70 „ „	150·5
80 „ „	161·5
90 „ „	175
Final boiling point	200
Recovery at 100° C.	18% vol.
Recovery at 140° C.	59% „
Total recovery	98·5% vol.

3. *Discussion of the Results.*—The effect of topping the oils to 100° C. is tabulated below.

TABLE IV.

I.	II.	III.	IV.	V.	VI.
Pennsylvanian ..	—	0·0003	0·0134	—	30° C.
Mid-Continent ..	4·6%	0·0072	0·0063	35° C.	does not
Persian	7·1%	0·0045	0·0174	29° C.	25° C.

Column I. shows the origin of the oil.

Colum II. shows the percentage by weight, removed by topping, and the figures are from Table III.

Column III. gives the change in specific gravity of the untopped oil during our experiments.

Column IV. shows the change in specific gravity consequent upon topping, and reckoned from the final value reached by the untopped oil.

Column V. gives the initial boiling point (vapour temperature) of the untopped oil, and the figures are from Table III.

Column VI. gives the approximate temperature at which the specific heat temperature curves for the topped and untopped samples begin to deviate from one another.

The deviation between the specific heat-temperature curves for the topped and untopped samples was originally attributed in some way to the lighter fractions, the suggestion being the generation of vapour molecules in solution when these were present. It now seems that this alone will not suffice to interpret the results obtained, for with the Mid-Continent oil the specific heat was unchanged despite the removal of 4·6 per cent. by weight on topping. Further, it was originally suggested that this deviation commenced in the neighbourhood of the initial boiling point (vapour temperature); but whilst this seems reasonable in the other cases, it breaks down for the Mid-Continent oil. This point was tested by making measurements of the total heat above this temperature[2] with fractions of 25° C. boiling range. The results did not indicate any marked deviation of the specific heat-temperature curve from linearity. In these tests, however, the oil had been de-ærated immediately before the measurements were made. From a recent careful series of experiments by the continuous electric flow method,[3] Jessel has concluded that the values of the specific heat obtained are lowered by thorough de-æration, and further he finds that for the de-ærated samples the specific heat-temperature curve is linear (except in the region where "solid" molecules are formed). When, however, the liquid is not de-ærated a peculiarly shaped curve is obtained, to explain which a tentative

[2] Lang, *J. Inst. Petr. Techn.*, 1930, **16**, 796; 1931, **17**, 581–584.

[3] Jessel, *J. Inst. Petr. Techn.*, 1931, **17**, 577–581.

theory was put forward in an earlier paper.[4] Both the Persian and Pennsylvanian oil (untopped) results are inclined to show such a shape, but it is not noticeable for the Mid-Continent oil. It is perhaps of some significance that this last named oil did not commence to distil until 147° C. (still temperature), whilst the corresponding figure for the Persian oil was 24° C. lower (Table III). Further the change of specific gravity of the untopped sample of the Mid-Continent oil is greater than that due to topping (Table IV.); but it must be remembered, as noted in the original paper,[5] that the sample topped, although drawn from the same barrel, was not the identical specimen that was used in the first series of experiments. It seems then that the original samples of untopped oils must have contained dissolved gas, but that in the case of the Mid-Continent oil, for some obscure reason, it did not influence the specific heat over the range of temperature covered. Apart from the fact that crude oils are known to contain considerable amounts of gas, a consideration of the changes of specific gravity lends support to the idea. These are much larger than those calculated by the ordinary mixture rules from the other data connected with the topping of the oils. Also the changes of specific gravity of the untopped oils during the series of experiments seem much too large compared to the change on topping to 100° C. to be accounted for solely by loss of the lighter liquid constituents. More expecially is this so, as in the type of calorimeter used no evaporation can take place as in an open type, and many precautions were taken to reduce to a minimum the losses from the other parts of the apparatus.

From the analytical results it will be seen that the larger the carbon residue (Conradson test) the smaller the specific heat; but no relation holds between the specific heat and the asphaltenes present in the oils.

The deviations from the specific heat—specific gravity equation proposed by Cragoe[6]—were given in the original paper (Table X.)[1], and these tend to support his statement, viz. : " The results on oils from mixed base crudes are in excellent agreement with the calculated values, whereas the results on oils from paraffin base crudes are systematically higher by about 2 per cent. on the average, and the results on oils from naphthene base crudes are systematically lower by about 2 per cent. than the value calculated from the equation." Whilst the deviations from the equation are in the same sequence, *i.e.*, napthene, mixed, and paraffin base types, there is a kind of

[4] Lang and Jessel, *J. Inst. Petr. Techn.*, 1930, **16**, 807.
[5] *Loc. cit.*, p. 496.
[6] Cragoe, Misc. Publications, Bur. Standards, No. 97, 1929, 26.

zero shift, in that it is the first type in the present case that agrees best with the calculated figure, while the mixed base type differs a little more and the paraffin base type shows the largest deviation from the calculated values.

4. *Interpretation of the Tests.*—I am indebted to Mr. A. Wolf for the following interpretation of the analyses.

All the crudes may be considered to consist chiefly of a complex mixture of liquid hydrocarbons, containing in solution a small amount of bitumen (asphaltenes) and small amounts of paraffin wax, except the Californian oil, which is wax free. The crudes may also contain dissolved gases or air.

The Pennsylvanian and Mid-Continent crude oils may both be considered to belong to the paraffin base type, inasmuch as the specific gravity of the 150°–300° C. (kerosine) fraction is only about 0·800 and that of the residue above 300° C. (vapour temperature, in the standard Engler flask) is below 0·910. The Persian oil examined is of the mixed base type, as indicated by the higher specific gravity of the kerosine fraction and especially of that distilling above 300° C. The high proportion of asphaltenes insoluble in alcohol-ether (4·2 per cent.) is to be noted, this test being more indicative of the bitumen content of the crude than the proportion of hard asphaltenes insoluble in aromatic free pertroleum spirit. The Californian crude oil may be described as of the asphalt base class, but of a type deficient in asphaltenes, being naphthenic rather than bituminous. It has the characteristics of the asphalt type inasmuch as it is deficient in fractions distilling below 150° C., and in that the kerosine fraction has a specific gravity well over 0·820. In addition the specific gravity of the residue above 300° C. is over 0·930, and the Conradson carbon value is high, being 5 per cent.

It will be seen from Table I. that the viscosities of the three wax bearing crudes are all of the same order, whilst that of the Californian crude oil stands quite apart, as is frequently the case with asphalt base crudes. Topping to 100° C. (vapour temperature) has roughly doubled the viscosity. Broadly speaking, the viscosities are in the order of the specific gravities, as is usually the case.

The acid values cover the normal range for crude oils. The marked increase in acid value consequent upon topping the Persian crude oil is probably due to the chemical decomposition of some of the less stable sulphur compounds which characterise this oil.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

TRINIDAD BRANCH.

A GENERAL MEETING of the Trinidad Branch of the Institution of Petroleum Technologists was held on March 18, 1931, when a paper on "The Chemical Aspect of Drilling Muds"* was read by Mr. Alexander Duckham, F.C.S. (Vice-President).

DISCUSSION.

Mr. J. L. Harris said that the first thing in the application of the use of heavy mud on fields was the presence of a central mud plant. Erection of central mud plants was particularly difficult and expensive, except where a field was large enough to afford one or compact enough to require only a single plant. Broadly speaking, erection of mud mixing plants was sound policy, but he was doubtful if every company in Trinidad could afford them. The cost of using barytes mud certainly amounted to $3 to $5 per foot, which was equal to the cost of putting casing in a well. Those figures are costs per foot excluding footage made without use of heavy barytes mud.

The author suggested the introduction of a chemist on an oilfield. It was, of course, a moot point whether a chemist knew any more than a physicist or a petroleum technologist regarding mud.

Mr. A. G. V. Berry said that Mr. Harris had rather challenged the necessity for the chemist, but the chemist's training was such that his services were essential, although the experience of the geologist and of the drilling man would also be advantageous, and he thought that this was a case for co-operation. The author was to be congratulated on showing some of the ways in which this co-operation could be applied.

In some parts of the world the cost of mud for an average well amounted to as much as $10,000, and apart from this expenditure the loss due to the use of an unsuitable mud might be enormous, due to caving, drilling troubles, distorted holes or even the abandoning of the well. There is, therefore, every reason for dealing with this question in a scientific manner, and it is really surprising that more in this direction had not been done.

The literature of drilling muds is very scanty, and realising the importance of this subject research had been started at Pointe-a-Pierre. Mr. Berry quoted some results made at their laboratory

* This paper was published in the March, 1931, issue of the Journal, pp. 153–182.

which established the fact that a mud which was too low in pH value would separate rapidly, but that by the adjustment of the pH value to the optimum (about 8·8 for Guayaguayare mud) by the addition of soda ash, the same mud would stand up for eight or nine days without showing more than 2 per cent. separation of aqueous fluid.

He thought that hydrogen ion concentration might possibly be adjusted to destroy "colloidity" and thus throw out the cuttings, after which the mud could be rendered alkaline again to obtain the optimum colloidity. This might even be applied in two stages when dealing with weighted muds, whereby the heavy and expensive material would be precipitated first by a slight lowering of pH value, after which another reduction in pH could be used for the removal of cuttings.

Another idea occurred to him, and that was the application of adsorption as a measure of colloidity. It was well known that the degree of adsorption attainable with a given clay depended upon the surface area of the particles. For a given weight of clay the surface area could be increased by diminishing the size of the particles, and thus the greatest degree of adsorption would correspond with maximum colloidity. It was suggested that the addition of measured amounts of, say, methylene blue solution to given weights of mud might be a ready means of measuring colloidity, if the aqueous fluids were separated by centrifuge and compared for residual colour. The sample of mud leaving the least colour in the separated liquid would presumably be the least prone to settlement.

The determination of hydrogen ion concentration on the field was quite possible by means of a colorimetric method in the hands of the chemist.

Mr. Moore said that the idea mentioned by Mr. Berry, for the measurement of particle size by the adsorption of a dye, had been receiving some attention in the last few days, but the right proportions of dye and mud had not yet been found. Several experiments had been carried out using insufficient dye. They seemed to show that the adsorption of dye gave an accelerated settling test which could probably be easily developed into a rapid test of optimum pH for use in the field, it could be easily seen from a quick test whether the clay was above or below the point of deflocculation.

The author mentioned the use of soda-ash in increasing colloidity and decreasing viscosity. The natural clays so far tested had a normal pH of below 8·2 when made into drilling mud. This was well below the optimum point for maximum colloidity and

the use of soda ash in the correct proportion would be beneficial whether barytes was to be added or not. The amount of soda to be added depended on several factors. The optimum pH of the mud in use, its original pH, its weight, and probably several other things, including what the chemist calls the amount of buffering. To illustrate the importance of accurate H-ion control rather than the addition of definite weights of soda ash he could give a few figures.

Two samples of mud taken from the same mud mixing plant at different times were diluted to weights of 71·5 and 73·2 lb./cu. ft. and each had an initial pH of 8·2. Addition of varying amounts of soda-ash gave pH values of 8·6, 8·9 and 9·2 in the lighter corresponding with pH values of 8·5, 8·7 and 8·9 in the other. This might not seem very serious, but it had been found that a variation in pH of 0·2 above the optimum value doubled the rate of settling while 0·2 below more than trebled it.

Another point which illustrated the increased colloidity of muds at the optimum point was that they took a much longer time to filter than muds with pH values on either side of the optimum. This difficulty in filtration should be comparable with the effect of the mud in plastering a porous formation.

Mr. A. H. Richard noted that the author did not think very much of the Trinidad viscometer, but he did not give any reasons for turning it down. It would be interesting to hear his reasons for thinking that it was not suited to its work. To him, as a matter of fact, it seemed that the Stormer viscometer employed a better principle for determining the viscosity of mud, but it appeared very much too delicate to use on the rig, where something was wanted that was more rugged and could stand a lot of hard wear, and something by which the determination could be obtained very much more quickly than by the Stormer viscometer.

Mr. J. W. Knights said that one thing occurred to him in the question of transport of cut, viscuous and sandy muds by pipeline. The lines should be of a standard size throughout ; where they had lines of different sizes, coating and settlement occur in the larger ones, and they needed frequent cleaning. Also with a central mud plant a two line system was necessary, one line for bad and one line for good mud.

Mr. H. D. Fletcher said that the author mentioned that barytes-laden or " doctored " mud would keep the cuttings in suspension, and so reduce to a minimum any settlement when circulation ceased either voluntarily or involuntarily. Though it may reduce this to a minimum, barytes-laden mud will itself settle considerably when

circulation ceases, and in deep wells may be sufficient to stick the drill-pipe if left for long without circulation or rotation. One of the advantages advanced by the makers of baroid, as against barytes, was that it did not settle so much, and so reduced that risk.

The author also stated that " To minimise the abrasive action of sand and rock particles in the pumps, etc., not only by acting as a lubricant, but also by obviating or reducing the entry of sand into a well." The entry of sand by caving in a well being drilled with heavy mud will seldom take place owing to the walls becoming plastered, but sand in the formation cut away by the bit or core cutter from the bottom of the hole must necessarily be conveyed to the surface and, unless it can be extracted between the well and the slush pit, will return to the pumps and cause the usual damage to the working parts. It therefore appears that the most suitable place for reconditioning the mud, if it can be done thoroughly and economically, is in the ditch between the well and the slush pit. Approximately 300 to 500 barrels per hour would have to be treated.

Referring to " blow outs " being caused by the expansion of gasses owing to reduced pressure as they near the surface, this is no doubt correct and may be observed when extracting cores of oil sand from the core barrel on the derrick floor, the trapped gas pressure in the barrel often being sufficient to blow the core out as soon as it is released.

The most valuable function of loaded or " doctored " mud is that it enables coring through high pressure sands, thereby locating their exact depth and extent. The perforations or screen can then be placed in the correct position to expose all the sands and obtain the maximum production.

Before the use of loaded muds, when wells were " drilled in " with a perforated oil string and wash pipe, it was very difficult to locate the exact depth of the oil sands, so there was always some doubt as to its thickness and how much was exposed.

Reconditioning of mud at a central plant, or preferably at the well itself, would no doubt prove an economy in most fields, and a further point in favour of doing it at the well is that it would eliminate the necessity for duplicate pipe lines, as would be the case in the central plant method.

Col. H. C. B. Hickling said that the author suggested that a viscous mud, in acting as a lubricant, might be an additional cause of deviation. Personally he did not think they need worry about that. Compared to the other factors that caused deviation, the lubricating value of mud was in practice of no importance.

Regarding the amount of gas that might be released from a section of core, the figures given were of great interest, but the effect

was largely minimised by the fact that the column of fluid did not remain stationary but was continually moving past the core being cut, and thus the gas was continually being carried away.

This was confirmed by the fact that in practice the difference in weight between in-coming and out-going mud was never such as would be expected from the figures in the table.

He hoped Mr. Duckham would tell them how the temperatures quoted were taken. Was the thermometer dropped down the well or were the temperatures those of the out-going mud ? He thought the readings were very low. Readings obtained within his experience from mud fluid on its return to the surface were much higher than those quoted.

He hoped the author would elaborate on the weak points of the Trinidad I.P.T. standard viscometer. They found it very satisfactory, being easy to use and understand, and it did give results without any trouble which were representative of the viscosity as it affected practical conditions. The driller could always check it by running water through. A case had been mentioned in which the mud frothed over the top of the container. This was quite immaterial; a good practical reading could be obtained even whilst mud was so frothing.

With reference to what he had begun to call the Dorr-Ventura system of reconditioning, he thought this was undoubtedly on the right lines. The author was concerned regarding the amount of water required for dilution, but practically all of this was recovered in the thickening process.

Colonel Hickling thought the barytes costs quoted were high. He thought the figures quoted were special cases and not cost based on total footage. He thought such overall costs in Trinidad were much lower ; in his own experience, 24 to 25 cents a foot for barytes was a fair figure.

Mr. B. M. Craig said that the author mentioned the use of a control value " to restrict discharge . . . and to check any tendency for the pressure to drop." Under these conditions, although gas cutting in the well might be reduced, emulsification would certainly occur as soon as the mud passed the control valve and the pressure was released. The emulsion formed under these conditions would probably be more stable than that ordinarily encountered and would thus increase the difficulty and cost of reconditioning.

He would also like to take up the question of the viscometer. This had already been raised by Mr. Richard and Colonel Hickling. Mr. Richard had said that the Stormer viscometer was a delicate instrument. Personally he was not acquainted with the instrument

in question, but from the description given he was inclined to agree with Mr. Richard that it would probably be too delicate for use on a well.

He admitted that the viscometer used in Trinidad might not give the true viscosity of the mud. This, however, was not essential. All that was required was an instrument capable of indicating a change in the condition of the drilling mud, and in his opinion the Trinidad viscometer was quite suitable for this purpose.

The author also mentioned that "although 300 mesh bartyes could now be obtained at the same price as 200 mesh, a still finer mesh barytes would be desirable." He did not quite agree with this. An increase in the fineness of the barytes used would result in a greater dispersion which would increase the viscosity of the mud. This was an undesirable feature and provided the barytes did not tend to settle out he considered the coarser and cheaper grade should be employed.

He regretted that soda only was mentioned as a reagent. He would have liked to have heard the author's opinion on other and, to his mind, more suitable reagents.

The essential feature of a reagent was that it should react favourably with all muds encountered in drilling. Soda reacted favourably with only some of the muds in Trinidad and for this reason he did not consider it a suitable reagent. He would recommend sodium silicate in preference.

Mr. Berry had mentioned the pH value of the muds. This was a very important factor and should be carefully controlled. He recommended the electrical instrument to Mr. Berry for determining this instead of the colour method he had described. He believed Mr. Berry would find this a more rapid and suitable method for this determination.

Mr. R. Godfrey asked for information upon the effect of contact of cement with barytes-laden mud, for the reason that he had on two recent occasions noticed that where wells were cemented from top to bottom the mud returning immediately preceding the cement was abnormally heavy and would not flow down the ditch.

Mr. H. C. W. Johnston said that they all had experienced a great deal of trouble with the heaving clays, and perhaps the ideas that had been put before them that night were going to enable them to overcome those problems. He thought that economically they had suffered a great deal in the past through inadequate knowledge of the properties that were required in drilling mud. It was only the last two months they heard about gel-forming colloids and that they were the most important thing in drilling.

The reconditioning of mud had been dealt with and, though the proposed layout was expensive for most of the fields, it was a matter which they would do well to bear in mind when they realised the cost of baroid.

He was very interested in the reference to the Dorr thickeners and classifiers.

Mr. A. P. Chamberlain observed that the author had calculated that a certain pressure or a certain column of mud was required to keep a specified gas in a liquid state, if it was mixed with another gas of higher boiling-point the pressure required to keep that mixture a liquid was considerably lower than the pressure required to keep the specified gas in a liquid form and, therefore, the column of mud required to prevent the liquid turning into a gas was considerably smaller.

For example, an equi-molecular mixture of ethane and heavy oil will be totally a liquid under a pressure slightly greater than half that required to keep ethane alone in a liquid state.

Mr. H. S. Conder said that some suggested that mud should be "doctored" at a central mud plant, while some advocated "doctoring" at the well.

Various methods of removing cuttings had been reviewed, some chemical, involving a colloidal reaction; some mechanical, involving the use of classifiers or screens. Cuttings, gas and oil would doubtless be best removed by a combination of these methods. Such a process would involve expensive plant and the attention of a skilled man. Could not this work be done more economically at a central mud plant, thereby saving much duplication of equipment and supervision that would be entailed if the work was carried out at the individual well?

During the earlier stages in the drilling of a well the mud can usually be kept sufficiently "thin" to allow the cuttings to settle out in the areas of low velocity in the ditch or to be removed by simple vibrating screens.

Later, however, when the bit reaches the oil sands and gas pressures have to be overcome, large quantities of heavy mud are often needed at very short notice. Surely it is better to be able to procure this mud from central storage and to return your old mud to be reconditioned than to spend valuable time reconditioning your mud at the well, a task that is often impossible to accomplish, leaving you with the only alternative of producing a heavy mud at the well, either by slow tank waggon transporation or by mixing the dry ingredients at the well.

Mr. G. H. Scott said that the main problems confronting the operator had been ably and concisely dealt with, but very little had been offered as a solution of these problems. There were several points with which he did not fully agree in the list of purposes for which mud is used. In No. 11 the author advances the theory that the lubricating properties of a mud tend to make a bit deviate from the vertical when drilling on a boulder. He did not consider the lubricating properties of mud tend to cause deviation so much as incorrect mud viscosity. Too thin a mud had a hydraulicing effect, which, if the boulder or hard formation was overlain by soft beds, would tend to enlarge the size of the hole and allow of the bit wallowing. This must facilitate deviation. Conversely with too viscous a mud the cuttings will not be entrained and will tend to collect at the bottom of the hole. These, if hard, may well tend to sidetrack the bit in soft formations. Again in No. 12 he considered that the use of mud in cementing is more one of expediency than of increased weight, speeding up the rate of cement travel. The advantage of the increased weight of a mud column is largely offset by the increase of friction as a result of increased viscosity.

There is one purpose for which mud has been used which has not received mention, *i.e.*, to bottom hole abandonments. A mud highly charged with bentonite or one of the proprietary equivalents will probably be just as efficient as cement in hindering fluid movement.

Blow Outs.—He agreed that some liquefied and dissolved gas is liable to be entrained with the rising mud column, and it is undoubtedly the primary cause for the gas cutting of mud. Quite apart from this, he suggested that there is a proportion of gas in either the liquid, dissolved, or gaseous state which is actually adsorbed by the mud. Colloidal suspensions have great adsorptive and absorptive properties, and most oilfield muds carry at least some colloidal matter.

Therefore it is quite possible that while much gas returns to the gaseous state on relief of pressure and can be removed by chemical means, some has been actually adsorbed and will not be affected by such mechanical treatment. If this premise is correct it would explain the gradual increase in the viscosity of a mud when drilling through a gas-bearing strata after the mud has been degassed by normal agitation methods.

As to the suggestion of placing a back pressure on the mud discharge, this was tried on the Apex field as long ago as 1928, and undoubtedly does aid in controlling the velocity of the upward travelling mud column. It necessitates drilling through a stuffing

box, which materially adds to the drilling time when many round trips are to be made, and is for this reason not liable to be widely adopted.

Gas cutting can undoubtedly be minimised by careful control of the mud weights and viscosities, and a *sine qua non* of correct practice is ensuring that the outgoing mud stream does not exceed the quantity supplied by the pump, as this naturally points to gas expansion in the rising column. The mud weights and, if possible, the viscosities should be given very narrow limits of permissible variation, and these mud qualities should be most carefully observed after a "round trip." Small additions of water if intimately mixed with the mud (preferably through a hopper) will greatly reduce the viscosity of a slightly gas-cut mud with no decrease in the mud weight. In fact, owing to the liberation of gas the weight is often increased.

The author referred to the use of steam for mixing. This is detrimental as it tends to destroy the colloidal state, and is best illustrated by the results of settling tests made on similar muds after a cold and hot mix, the time of settling being 14 hours in each case :—

	Cold mix.	Hot mix.
Clay "A"	0·61% free water.	18·92% free water.
" "B"	12·79% "	48·48% "

Those with experience of the treatment of slimes in ore dressing will know that heat is often used to bring down the suspended matter.

The author did not stress the importance of finding the best natural clay for mud mixing. Thus constancy of specific gravity is a very important factor, and the settlement properties and viscosity figures for muds of equal weight may vary widely.

He had made up two muds weighing 84 lbs./cu. ft., one of weathered forest clay and one of the unweathered clay, and obtained the following viscosities with the Trinidad I.P.T. viscometer :—

Weathered	31·0 secs.
Unweathered	21·2 "

These muds were allowed to settle for 14 hours and the percentage of free water measured :—

Weathered	12·79% free water.
Unweathered	0·61% "

This test indicates how one and the same clay may vary. Incidentally these tests contradict the statement that the deeper one goes the worse the resulting mud.

The criticism launched at the Trinidad I.P.T. viscometer as to its unsuitability for measurement of gas cut muds is hardly justifiable. These instruments were designed to give the driller a means of knowing whether his mud was remaining constant in fluidity and to check increases. The instance given of the viscometer remaining full after the test quantity had been run off prompts the criticism that the mud should not have been allowed to reach that condition. A viscometer is not necessary to prove such a mud to be gas cut.

The best definition of a colloidal state was one given in an article appearing in the *Oil and Gas Journal* of October 16, 1930, *viz.* : "When the state of division approaches a molecular simplification the condition is known as the colloidal state."

There are two ways of increasing colloidal quality :—(1) By an admixture to combine with the water of mud to form a gel ; (2) by an admixture which gives a chemical reaction with the mud particles. The former method gives a more stable suspension but a very increased viscosity ; the latter is very easily broken down by peptising electrolytes, heat and other agencies.

He agreed with the author as to the harmful effects of carbonates in barytes. These, of course, lower the specific gravity of the sample, but have the more serious effect of greatly increasing viscosity.

Thus, in an experiment, the following results were obtained :—

Sample "A." Sp. gr. 3·79 ; Carbonates, 17·28 per cent. ; Viscosity of 94 lb. mud, 30 secs.

Sample "B." Sp. gr. 4·16 ; Carbonates, 9·35 per cent. ; Viscosity of 95·25 lb. mud, 14 secs.

Barytes is now purchased to conform to the following specification :—(1) Specific gravity shall not be less than 4·15 ; (2) the residue by weight shall not be more than 2 per cent. on a 300-mesh I.M.M. screen ; (3) the percentage of barium sulphate by weight shall not be less than 90 per cent.

He was under the impression that the effect of soda ash was mainly that of base exchange of calcium salts to the more fluid sodium salts. If so this will mean that only a definite amount is required to perform this chemical reaction. Any excess will tend to peptise the colloidal matter and increase viscosity. With a plain barytes mud there is no such interaction, so soda should be used with the ordinary clay mud prior to barytes loading.

The soda ash has been abandoned as it needs very careful control and does not confer any lasting effect on the viscosities.

The author has not referred to the use of sodium silicate for reducing the viscosity of a mud, and he desired to amplify the remarks on salt water attributed to him.

A good mud in the presence of a normal salt water sand does not generally increase in salinity above a figure of 0·2 per cent. NaCl. and will mud off the sand before any undue dilution and coagulation take place. If gas is present and a flowing water results this is not the case, and only a loaded mud will control it.

An excess of positive ions in the mud will only cause coagulation provided that the colloidal suspension is a negative one, and this coagulating effect varies directly as the valency of the ions. Sodium being a monovalent ion has only a feeble coagulating power. If the suspension is a positive one it will be coagulated by negative ions. An interesting instance of this phenomenon is in the water treatment plant where the very fine suspended matter is brought down by the coagulating action of alum. If the water is slightly acid there is absolutely no coagulating effect, and the pH value has to be raised to 7· by the addition of soda ash for the optimum effect.

There is a similar problem in the addition of sodium silicate to a mud. Thus, if a mud has a pH value of 7, i.e., slightly alkaline, this salt certainly improves viscosity, but if the mud shows an acid reaction, *i.e.*, pH value below 7, thickening will result.

Reconditioning.—While screens will remove the larger particles of sand and cuttings, there will be a certain proportion that will not be removed by such means, and drastic dilution is then necessary to remove them.

In a test carried out with unloaded mud of 86 lb./cu. ft. containing 20 per cent. of sand by volume, dilution to 70 lb./cu. ft. was necessary to reduce the sand content to 1·0 per cent. Incidentally, when the sand had been reduced to 8 per cent. the mud sample stood overnight and there was absolutely no additional settlement.

Such dilution will adequately degasify mud and will remove any entrained oil if the water addition is carried out through a hopper.

It would obviously be impracticable to carry out such dilutions at the well and a central plant would be necessary. After dilution the mud must be dewatered and a settling test on the 70 lb./cu. ft. mud showed 29·7 per cent. of free water after fourteen hours' settling. This settling action can be greatly accelerated by bringing the pH value of the water to 7·2 and adding alum. The effect of this can be gauged from the following results on the 70 lb./cu. ft. mud from the test previously mentioned.

Time of settling.	Untreated mud.	Alum-treated mud.
15 mins.	4·0% free water.	47·7% free water.
14 hrs.	29·7% „	61·2% „

This will naturally destroy the colloidal quality, but it is suggested that the addition of bentonite in the proportion favoured by Mr. Beardmore should recondition the mud.

Mr. R. N. Kirby said that it might be of interest to know that barytes was used in 1924 in Ventura, California, where he saw it for the first time. A mud of 70 lb. was usual, but by the addition of barytes they obtained a mud of 92 lb. which at that time appeared to fulfil the conditions encountered. In view of the cost mentioned at the end of the paper it is of interest to remark that barytes at that time cost about $12.00 per ton on the field.

Further, to Mr. Scott's reference to the use of mud as a permanent water shut-off he would like to know whether the author advocated for this purpose, a colloidal or a heavy non-colloidal mud.

Mr. W. J. C. Cooke said that he felt that the author, in assuming that the drilled up portion of the oil sand was responsible for the preliminary lightening of the mud column, had hit the nail on the head, but he thought that there must be other contributory factors, otherwise there would be a simple way out of such troubles.

For instance, in considering the case of a well where the oil sand had just been tapped, the gas pressure being less than that exerted by the mud column as suggested, drilling would be stopped until such time as the gas-cut mud created by the few inches of sand disturbed had reached the surface before another small portion was drilled out and the operation repeated. Thus, the reduction in weight of the mud column would be kept within reasonable limits by the addition of but a small quantity of new mud.

He considered, however, that such a procedure would in all probability be more likely to cause a blowout than to prevent one, because he had found that in drilling through thin oil sands they were apt to have as much trouble with gas cutting as was the case when thicker ones were encountered, the pressures being as far as they knew identical; also, as a general rule when circulation was stopped for a short period after entering an oil sand, the mud was found to become gas cut extremely quickly, unless it was of such weight as to exert a much greater pressure than the gas pressure of the well.

In connection with such primary gas cutting of mud he did not know whether it was a general rule with drillers to commence pulling out of the hole slowly or not when they had encountered an oil sand, but on the two or three occasions on which he had witnessed such a procedure, the cutting of the mud had not been as severe as was usual when the extraction of the drill-pipe was commenced rapidly.

Mr. C. C. Wilson said the author had mentioned that clay taken near to the surface formed better drilling mud than clay taken from depth. Was the reason for this that clay from near the surface is weathered ?

In regard to coring, the core while being taken at the base of the well in an oil sand is under pressure due to the weight of the column of mud, therefore, as Mr. Duckham pointed out, contains gas in solution in the oil.

The author said that cuttings do not release their gas until they reach a level in the well where the weight of the mud column is sufficiently reduced.

It would seem far safer, therefore, to imprison the cuttings as is done in the core barrel, with their gas in the dissolved state until the barrel is opened on the derrick floor.

It appears, on this argument, that continuous coring reduces gas cutting and the resultant risk of blow-outs to a minimum.

The Chairman said he would close the discussion by congratulating Mr. Duckham on his courage in coming to Trinidad and reading a paper on a subject of which each of those present had practical knowledge and on his audacity in attacking an invention for which they were all responsible and all in agreement that it satisfied the purpose for which it was evolved.

He felt that some of the study devoted to the better use of heavy laden mud could be, with advantage, directed toward the elimination of its use. If, however, the evil was to be perpetuated he suggested that its useful phases be taken advantage of.

For instance, barytes laden mud was credited with sealing off oil sources; therefore, why should that feature not be adapted to sealing off water sources ?

To-day, it was common practice to replace heavy mud with cement, which certainly provided a more dense medium; but was it not possible that the heavy mud was equally or more effective ? If it was so, why, when isolating oil and water, should the mud not be left in place at the back of the casing and by saving the cost of cementation reduce the reckless expenditure with which the author charged the industry ?

On four separate well cementations recently he had noticed that cement had reached a point 60 per cent. higher than by computation it should have done. Explanation must lie in the fact that the diameter of the drilled hole was reduced by the plastering effect of the heavy mud, in which case whilst it might be accepted that the cement formed a close bond with the casing it could not be held to do so with the wall of the drilled hole, therefore, isolation of the water was still dependent upon the annulus of mud lying between the cement and the wall.

The useful purpose of cement under such conditions could be only to reinforce or preserve the casing, a valuable asset in some unfortunate fields but unnecessary in others.

Again, if the use of barytes-laden mud could not be entirely eliminated he suggested that by the practice of reverse flush a lesser quantity would be called for.

At present, by pumping mud down the drill-pipe and allowing its return by way of the annulus formed between drill-pipe and casing, all gas released by drilling through oil sands rose to the surface in the rising mud, reducing the weight-holding sands of explosive character under control.

If reverse flush was practised the pressure exerted by the heavy mud would remain constant as the larger volume of mud would maintain its full controlling effect upon the face of the sand. Gas would be released only by way of the drill-pipe acting as a vent.

The Author (Mr. A. Duckham), in reply, asked the meeting, and especially the Chairman, to remember in the first instance that he had not originally contemplated being so audacious as to read the paper in Trinidad. It had been intended for London, and this for the especial reason that he had criticized to the Council the fact that the Journal contained so little about field operations, and thereupon had been asked why he did not contribute papers on that subject. And thus it came that he wrote about "Mud." Subsequently it occurred to him that in Trinidad he might sit once more "at the feet" of the gentlemen from whom he had learnt so much on the subject of mud and put before them the results of their teaching.

His criticism of the Trinidad Viscometer had been questioned by more than one speaker. What he held was that it was better than nothing for use by a driller, but that for accurate work it was useless. The evolution of gas rendered the mud spongy ; frothing from the viscometer was another trouble, as was the variation in rate of flow owing to the passage of large particles through the orifice tube, and indeed in some cases its complete blockage. These were only a few of the obvious shortcomings.

Mr. Harris took exception to the introduction of a chemist, but the Author could not see how anyone but a chemist could be expected to deal with the known chemical problems, and still more with the unknown which obviously needed research. He was glad to have Mr. Berry's support in this matter. The latter gentleman had put forward an interesting suggestion with regard to the use of an indicator such as methylene blue for measuring colloidity. This was touched on also by Mr. Moore, and it was to be hoped that these gentlemen would persist and be successful in evolving a simple and reliable application.

The Author felt that Mr. Moore's remarks were an indication of the great value that came from having these papers discussed by

practical men, because they were able to supply actual data from personal experience; such data, indeed, as was not otherwise published. This is borne out by the contributions of the majority of the speakers.

Mr. H. D. Fletcher was the first speaker to touch on the theory as to blowouts being caused by the compressed gases assuming a gaseous condition as the pressure is reduced in rising to the surface; and although the Author had heard of trapped gas in the cores exercising almost explosive violence, yet he had not before connected it with this theory.

Colonel Hickling disagreed with him as to a lubricant tending to increase the liability to deviation, but he would stick to his point, and he felt that he with muddy shoes would be more liable to slip off a boulder, and so, in his opinion, would the bit. When attention was drawn to the probability that the gas was continually being carried away in the moving mud, he raised a point which the Author had not taken into account.

As to the method of taking the temperatures, these were done by dropping a thermometer down the well to the depths indicated and allowing them to remain for an hour before raising for reading. The work was carried out under the supervision of the Mines Department.

Colonel Hickling's barytes costs were certainly much lower than any of which the Author had heard, and he (the Author) could not help thinking that the conditions of use on the Apex field must be less onerous than elsewhere.

Mr. Craig's idea, that if a control valve were used to restrict discharge the emulsion might remain more stable, did not appeal to him, and he felt that the sudden release of the mud in the open might be an excellent way of reducing the gas contained, and so the cost of reconditioning.

He entirely disagreed with Mr. Craig when he opposed the increase in fineness in barytes on the grounds that greater dispersion would increase viscosity of the mud. Surely it was accepted that the finer the barytes the better, because thereby it approximated the more to a colloidal condition, and he believed that it was generally agreed that the only limiting factor to fineness smaller than 300 mesh was the question of cost of manufacture. The same gentleman regretted the absence of information about what he terms "more suitable reagents than soda." This was the sort of information which it was the object of the paper to elicit.

The Author felt that he could offer no useful opinion on the facts mentioned by Mr. Godfrey, that mud returning immediately before the cement was abnormally heavy.

Mr. Johnston's remarks were very gratifying, because he expressed the opinion that the paper may serve a useful purpose, not only from a technical aspect, but also from the economical. He, like Colonel Hickling, supports the use of thickeners and classifiers, and their opinion must carry weight in view of their practical experience. The desirability, or otherwise, of having a central mud plant was raised by Mr. Conder, as it was by other speakers, and the Author felt that his practical experience was not of real use, but he could not help thinking that those responsible for the general management of a field could very quickly sum the situation up in L. s. d. and decide whether it was to be recommended for the individual fields or for a co-operative system between a number of fields.

The Author felt that by common consent Mr. Scott's contribution to the discussion would be acclaimed as of outstanding value, and he took that opportunity of saying that he had wished to give pride of place to Mr. Scott in the compilation of the Paper, had Mr. Scott felt that he had the time for its writing. Unfortunately he had not, but they were fortunate at that meeting in having placed at their disposal the opinions and figures which he had put before them.

Mr. Kirby goes back to the date of 1924 for early use of barytes, and probably it would be found that its inception was considerably before that. His inquiry as to the pros and cons of the colloidal or non-colloidal mud for shutting-off purposes was of great practical interest, and the Author had no hesitation in stating his opinion that for a permanent shut-off the pros must be with a heavy non-colloidal mud, because we know that such muds, on standing, deposit the heavier constituents which, under the existing pressures, are consolidated in the form of a rock. For temporary shut-offs one would generally advocate a colloidal mud, because then there would be a minimum of settlement and one could, with least trouble and expense, recommence operations.

Mr. Cooke advanced a very interesting and—coming from such practical source—noteworthy method of reducing the liability of severe blow-outs by occasional stopping of the drilling. This needed careful consideration, in spite of the fact that he himself criticised it on the grounds that his experience showed that there is a liability to trouble with the thin oil sands as with the thick, in spite of identical pressures. The question he raised as to the drillers pulling up slowly or otherwise, and its effect on cutting of the mud, was surely one which could be tested out in the Island.

Mr. Wilson's question about the variation of clay at depth must be answered by saying that there was published information to the effect that clays suitable for the making of mud generally ceased to exist at the greater depths, by which is meant beyond, say, 2000 ft.

and the Author did not have in mind the question of just a superficial variation at surface, such as might result from weathering.

The Chairman's advocacy of endeavours to eliminate the use of mud appealed to the Author, who felt that it was only a passing phase, and a somewhat clumsy one at that, for overcoming a trouble which would, in due course, be handled more effectively.

The Chairman asked why barytes mud could not be used for sealing-off water sources, and the Author remarked that surely this was common practice, and that he had understood that it was accepted by the Mines Department. His (the Chairman's) practical experience in various directions gave food for thought and was evidently a valuable contribution.

The following contribution has been received from Mr. H. F. Warrington Morris:—

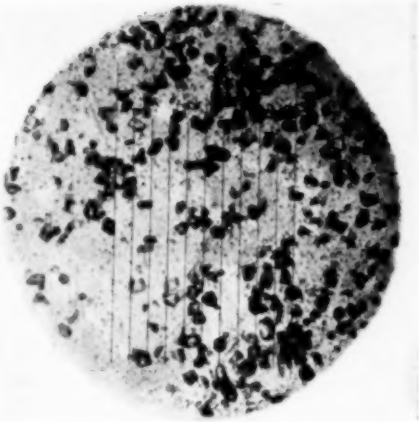
I have read with great interest the paper by Mr. Alexander Duckham, entitled "The Chemical Aspect of Drilling Muds," and I should like to be permitted to make a few observations in regard to barytes, which might be of use to my fellow members. I hasten to state that I have no criticism to make of the paper; I appreciate the manner in which Mr. Duckham has so ably handled the subject, but as I have been engaged for the last four years in a very close study of the barytes industry from all points, and have had much previous experience as a rotary driller, I feel I can speak with some knowledge of the subject.

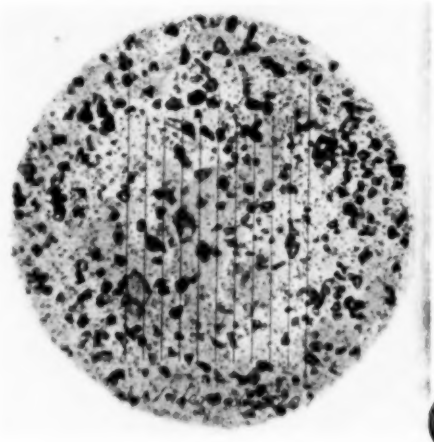
Barytes appears to have been first used in 1923 for "doctoring" mud, in the United States, and apparently the earlier trials were made without much attention being paid to the $BaSO_4$ content of the mineral, which, of course, is practically the most essential point. Barytes with a low $BaSO_4$ content is not only less efficient for "doctoring" from a specific gravity point of view, but from the fact that the most abundant impurity associated with it is silica (SiO_2), and however finely it is ground any excess of silica is most deleterious.

As the specific gravity should be at least 4·2, it naturally follows that the minimum $BaSO_4$ content should be 95 per cent., and I am of opinion that the time has come for a definite specification to be laid down for "Barytes for oil well use," just as it is for paints, etc.

There is no difficulty whatsoever in obtaining barytes which contains 95–97 per cent. $BaSO_4$ and under 1 per cent. SiO_2, which would appear to be as nearly perfect as possible for the ground natural ore.

The present production of barytes is about 750,000 tons per annum, of which Germany and the United States produce 300,000





UNIV. OF MICH.

tons each. The British production is about 50,000 tons, and the remaining 100,000 tons is produced in France, Italy, Spain, Japan, India and Australia.

Mr. Duckham states it is regrettable that the German deposits yield a superior quality to those found in England, which is correct as referring to England only. In Scotland and Ireland, however, particularly in the latter country, there are deposits which are superior to the majority of German deposits, and equal to the best.

A mine now being developed in Ireland by a British company has one of the finest lodes known, with an average $BaSO_4$ content of 97·3 per cent. in the crude state. After being treated the resultant ground product shows 99 per cent. $BaSO_4$, *i.e.*, the specific gravity is 4·4, and under 0·75 per cent. of SiO_2; furthermore, it is a perfect 100 per cent. 300 mesh.

The deposits in Scotland produce a fine ground material analysing 96·3 per cent. $BaSO_4$ (or 4·3 specific gravity) and 1 per cent. SiO_2, but the mesh size is only 250. This, however, is a matter of improvement in grinding methods.

It is satisfactory to know, however, that Great Britain is in a position to compete with Germany or any other country in this important business.

In the treatment of barytes for the production of fine ground barium sulphate it has been definitely proved in recent years that air flotation, for final separation, is far superior to levigation, inasmuch that a much more even fineness is obtainable, also from the fact that by using the proper plant it is a much simpler process.

Naturally, this air flotation is a highly technical process, but by constant experimenting it has now been brought to a very high stage of perfection, and, although it cannot be said that we know *all* about it yet, present methods leave very little room for error.

In the determination of mesh size up to date producing companies use the Ramsden micrograph, designed by Lt.-Col. J. V. Ramsden. This ingenious instrument is in the form of an inverted microscope, which has its eye-piece at right angles to the object glass, with a prism interposed, the field being brought into focus through the bottom of a Petri dish. The whole field is visible on a mirror with a magnification of 180 diameters. The samples to be examined, taken from each bag produced, are shown in conjunction with a graticule to required scale, and the mesh size grade can be immediately determined. It is possible to grade correctly some 70 to 80 samples per hour with ease.

By the use of this instrument it becomes possible to definitely guarantee any 100 per cent. mesh size required.

Incidentally, a permanent record of any sample can be obtained in the form of a microphotograph by a slight adjustment of the lighting arrangement.

Typical examples are shown in the microphotographs of a 300-mesh product. The faint parallel lines are spaced to represent 300-mesh.

The following analyses may be interesting and useful. They are taken from average samples representing sources named :—

	German barytes. (1)	English barytes. (1)	Irish barytes. (1)	Scotch barytes.	Baroid, U.S.A.	Plastiwate California Talc Co.
$BaSO_4$.	96·20%	92·5%	98·25%	96·3%	86·5%	83·5%
SiO_2 ..	3·20%	4·7%	0·75%	1·0%	6·2%	8·7%
Fe_2O_3 } Al_2O_3 }	0·25%	0·75%	0·35%	0·5%		3·8%
$CaSO_4$ ..	0·05%	1·0%	0·55%	1·75%		1·5%
$CaCO_3$.		0·8%		0·25%		0·1%
Mesh ..	300	250	300	250	200	200
	(2)	(2)	(2)			
$BaSO_4$.	94·3%	95·0%	97·3%			
SiO_2 ..	5·2%	2·0%	1·2%			
Fe_2O_3 } Al_2O_3 }	0·2%	1·0%	0·4%			
$CaSO_4$ ..	0·3%	0·5%	0·5%			
$CaCO_3$.			0·05%			
Mesh ..	250	200	300			

In conclusion I would state that I shall be pleased to furnish any of the information re barytes which I have at my disposal should any of the members require it.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.

RUMANIAN BRANCH.

THE THIRTY-SECOND GENERAL MEETING of the Rumanian Branch of the Institution of Petroleum Technologists was held at Ploesti on April 24, 1931, when the following open discussion took place on the "Behaviour of Restricted Wells."

Mr. G. Elias (in opening the discussion): Early last summer a number of companies found themselves in the position of having more production available than their organisation could handle, and so it became necessary to shut in a certain amount of production. Rather later, the restriction of production was put into force, and as the country's allowable production was less than the total handling capacities of all companies, the amount of production that had to be closed in was increased, in fact some companies were obliged to shut in as much as 50 per cent. of their available production.

Companies' managements were then put into the position of having to decide which wells would be restricted or entirely shut in and which should produce normally. The main consideration in determining which wells should be restricted were:—1, Quality of crude; 2, The activity of neighbouring development; 3, Lifting costs; 4, Mechanical difficulties in restricting wells; 5, Dangers of losing ultimate production by restricting wells.

It occurred to many of the technical men concerned with putting restriction into effect that it is nearly as difficult to restrict production below a limit as it is to raise it above a limit.

A number of production engineers were aware of the probable truth of the fifth of the above considerations, namely the dangers of losing ultimate production by restricting wells, and this aspect of restriction must be one of the subjects to be discussed.

In considering my own experiences with flowing wells which have been restricted I found that they fall into three classes:—

1. Those which appear to have suffered negligible decline during the periods they have been restricted.

2. Those which appear to have declined during restriction periods at about the same rate as they would have declined if produced normally, and

3. Those which, at the end of a restriction period are almost certainly smaller producers than they would have been if they had produced normally.

I will give you a concrete example of each of the above cases.

Diagram "B" is the production curve of a well producing from the 3rd Meotic sand in Gura Ocnitei, on the northern part of the structure.

This well was put into production in May, 1930, and immediately before restriction was producing as follows:—

28 cars per day, 12 mm. bean, 55 atm. in casing and 53 atm. in tubing, and a gas-oil ratio of 100.

During August she was producing 3-6 cars per day through 5-, 5½-, and 6-mm. beans, 48 atm. in casing and 53 in tubing, and a gas-oil ratio of about 90.

At the potential test in September she produced 41 cars per day through a 17-mm. bean, 64 atm. in casing and 46 in tubing, and a gas-oil ratio of 90.

For nearly two months she produced through a 4-mm. bean except for 5-mm. bean on one occasion, giving 1-2 cars per day, 40 atm. in casing and 48 in tubing, and a gas-oil ratio of about 110.

On November 9 she made 26½ cars through 13-mm. bean, 34 atm. in casing and 48 in tubing, gas-oil ratio about 90.

On December 2, she made 35 cars, but gauged 40 cars for a few hours through a 17-mm. bean, so that her condition since the September potential test had not changed, except that casing pressure was 46 and tubing 48, instead of 64 and 46 atm. respectively.

She was then produced through 9 to 11-mm. beans, for the most part, until March 8, when she produced 37 cars per day through a 16-mm. bean, with 52 atm. in the casing and 44 in tubing. With a 17-mm. bean she would have attained her September potential figure.

Here, then, we have the case of a well capable of giving 40 cars per day, which was restricted for periods down to 1 car per day which gave 2,100 cars between September and March potentials, yet showed no decline at all except atm. in tubing pressure. The figures for casing pressures must be discounted in all cases due to a peculiar condition existing here.

It should be noted that the above well is in a newly-developed area and has been little affected by nearby wells, although at some distance there are a number of wells producing higher up structure.

Diagram "C" is the production curve of a 3rd Meotic sand well in Bana South. Until December, 1930, this well was not very close to other producers, except one at about 120 metres.

Immediately before restriction this well produced over 28 cars per day through 15 plus 13-mm. beans (equals one 25-mm. bean) with 85 atm. in casing and 31 in tubing. At the September potential test she made 20 cars per day through 19 plus 20-mm. beans (equals one 28-mm. bean) with pressures of 75 and 25 atm.

From then until November the well produced through a 7-mm. bean and casing fell from 85 to 76 atm. and tubing from 72 to 62.

A potential test on November 14th gave nearly 15 cars through 18 plus 18-mm. beans (equals one 25-mm. bean) with 69 atm. in casing and 26 in tubing, the gas-oil ratio being about 400 as compared with as much as 1500 when flowing at 1–2 cars per day.

Since then the well has been going full out, and during March was giving about 8 cars per day through 18 plus 18-mm. beans (equals one 25-mm. bean) with a gas-oil ratio of about 800 and pressures 47 in casing and 16 in tubing.

This well shows very marked decline in production and, as is to be expected in pressures. The pressures were even declining during the time the well was restricted to 1½ cars per day.

In my opinion the production decline would not have been more marked if the well had produced all out continuously, *i.e.*, a curve drawn through the potential peaks would approximate to the normal decline curve. If this assumption is correct, then do the areas between potential peaks represent lost or deferred production ?

My own opinion is that it is mostly, if not totally, lost, and in this case represents a quantity of 1750 cars. If so much production is lost, where has it gone ? A possible explanation is that thief sands in the 3rd-sand complex might be responsible.

It is to be expected that thief sands will take more oil when the well is restricted than when it is going all out. The greatly increased gas-oil ratio usually noted in restricted wells is very clearly demonstrated in this case, where the ratio was 400 when the well flowed at 15 cars per day but 1500 when restricted to 2 cars per day during October.

Diagram "A" is the curve of a well in the 3rd Meotic sand in Gura Ocnitei on the northern part of the structure and located high up on it, accounting for the high gas-oil ratio here.

At the potential test the well gave 16·7 cars through a 15-mm. bean with pressures of 55 and 48 atm. On being closed to a 5-mm. bean the pressures rose to 80 and 64 atm., but by November 1st had fallen to 76 and 46, still through a 5-mm. bean.

A potential test in November gave 13·1 cars through a 15-mm. bean with pressures of 75 and 32, and again in December 11·2 cars, also through a 15-mm. bean with pressures of 46 and 34 and a gas-oil ratio of 430.

In the latter part of January the production was 1½ cars through a 9-mm. bean, pressures 58 and 55, gas-oil ratio 2200.

On February 9th the well was closed in with a pressure of 55, which fell to 45 before opening up on March 9th. On opening up the well, the production slowly increased to 3 tons per day

after a few days, the gas-oil ratio being 7000. Bean increases to 9- and 10-mm. gave only increased gas-oil ratio and no increase in production.

Further bean increases to 14-mm. only brought the production up to 2½ cars. Finally, with 19-mm. production was raised to 4½ cars per day, gas-oil ratio being 2000 and pressures 35 and 30 atm.

It is evident that the shutting-in of the well was detrimental to it and it puts this well into the third of the classes mentioned, namely, that of wells which decline probably more than they would have done if produced continuously all out.

I understand that production engineers have found that wells high up on the structure and with big gas-oil ratios come back very badly after being closed in, and I understand that there are cases of such wells in Moreni which yielded only gas after being closed in for periods.

It is hoped that this discussion will give probable reasons for this phenomenon, which, in my opinion, is due to drainage of the oil down the structure and so increasing the area of the free gas zone as to bring these wells within it.

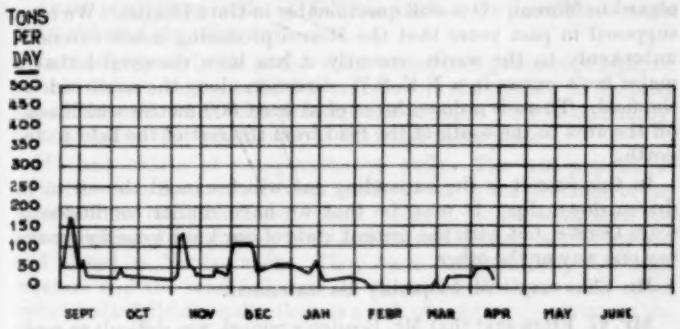
I would like to draw attention to a statement in the United States Bureau of Mines Book on the Function of Natural Gas, to the effect that evidence shows that in fields where edge water is the main lifting agent wells will not, generally, decline when shut in, but where gas is the main lifting agent, wells which have been restricted will frequently come back with the production they ought to have had at that date if they had been producing unrestricted; in other words, the production would rise to the normal decline curve of the well. This contention is illustrated by wells "B" and "C" "B" (in Gura Ocnitei) being in a pool which, according to present evidence, is not under the influence of edge water and has a free gas zone.

Mr. Boaden said that with regard to well "A" Gura Ocnitei, at the time it was producing at the latter part of its life, three wells were producing almost wide open at the top of the structure with big beans and very much gas. It seems that if the oil is being driven away down the structure these wells producing much gas higher up on the structure should more or less compensate for that.

The well illustrated by diagram "B" is producing on the same structure but much further down the dip, a matter of 300 or possibly 600 metres distant. Very small loss of potential is due to big drainage area and the effect of the water drive.

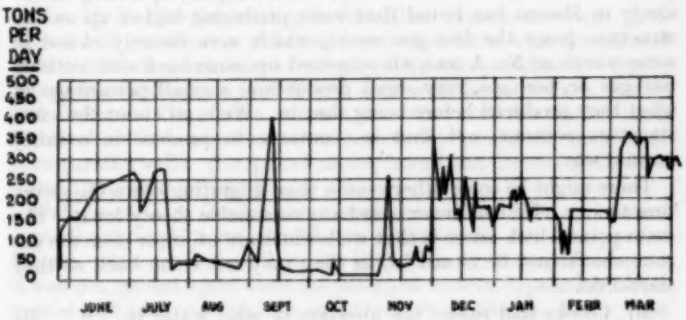
Mr. Crooks said that, relative to Mr. Elias' statement that "in Gura Ocnitei the expanding force was probably due to water

A.


TONS PER DAY
500
450
400
350
300
250
200
150
100
50
0
SEPT
OCT
NOV
DEC
JAN
FEBR
MAR
APR
MAY
JUNE

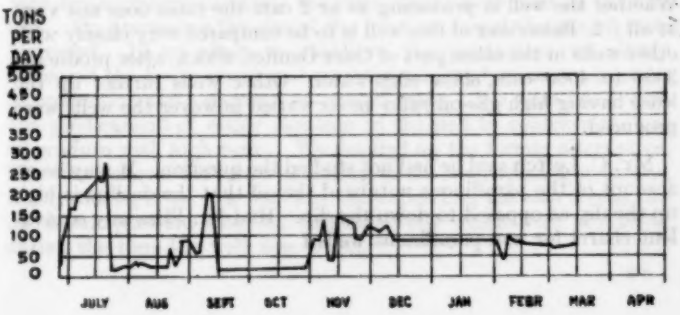
A.

B.


TONS PER DAY
500
450
400
350
300
250
200
150
100
50
0
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEBR
MAR

B.

C.


TONS PER DAY
500
450
400
350
300
250
200
150
100
50
0
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEBR
MAR
APR

C.

drive and in Moreni due to expanding gas pressure," he agreed in regard to Moreni. It is still questionable in Gura Ocnitei. We have supposed in past years that the Moreni-producing sands extended unbrokenly to the south—recently it has been discovered that a major fault passes in a N.E.-S.W. direction along the south side of the field. There is a downthrow of at least 500 metres which seals off the area to the south of the field from the rest of the field to the north.

In this case it is the expanding gas which caused the oil to be driven down dip. It may be that we have similar conditions in Gura Ocnitei, but with the present state of our knowledge we cannot say one way or the other.

Mr. Elias may wish to qualify his statement.

Mr. G. Elias said that Mr. Boaden's remark was difficult to reply to. It seems rather curious that wells which were as high up on the structure as " A " should not have suffered from drainage, but the point is that they were not shut in. One company operating extensively in Moreni has found that wells producing higher up on the structure (near the free gas zone), which were entirely closed in some weeks, as No. A was, when opened up came back with nothing but gas or, perhaps, very small production, a small percentage of what they produced before being shut in. Wells on about the same structure contour, not shut in, continue to produce in a fairly normal way.

There might be some other reason than migrating down the structure theory. He had never heard any reasonable theory for it. The main point which arises is that wells which are at, in, or near the gas zone should not be closed in, as they may not come back as they should do.

Mr. Crooks had raised the question of edge water in " B." He (Mr. Elias) believed that the edge water in this particular case is the main lifting agent, and his evidence for saying this is based upon two points: 1, Gas-oil ratio is very low—90 or 100 all the time. Whether the well is producing 40 or 2 cars the ratio does not vary at all; 2, Behaviour of this well is to be compared very closely with other wells in the other part of Gura Ocnitei, which, after producing 3000 to 4000 cars, show edge water. Other wells further up the lease having high gas-oil ratio never varied however the wells were produced.

Mr. C. Leitch said he had not studied the question. It may be on account of the paraffinous nature of the oil that the decline is high up the dip as opposed to down the dip. Had Mr. Elias any equivalent charts for non-paraffinous wells ?

Mr. Elias said that the question of paraffin certainly enters into the case of all these wells. "C" has much more paraffinous crude than either of the other two.

In the fairly early life of the wells, whilst rock pressure is high, he did not believe that paraffin has an effect on the sands; in the later life of the well, when rock pressure has dropped very considerably, it is probable that paraffining of the sand takes place.

He had charts of non-paraffinous wells. The non-paraffinous wells have not been restricted so much, owing to the demands of the refineries for non-paraffinous crude. Also it would seem that the non-paraffinous (producing from Drader sand) could not be opened and closed as Meotic wells. They have comparatively low rock pressure and the sand is loose. If we deal with these wells as we have handled Meotic wells, there is a risk of sanding up, owing to the instability of the Drader sand.

He had no curves to offer on the behaviour of the non-paraffinous and paraffinous wells.

Mr. H. F. Crooks, adding to Mr. Elias' statement re non-paraffinous and paraffinous wells, said our experience with paraffinous wells is that they act more erratically than non-paraffinous—this in comparing decline curves of Baicoi wells with those of Gura Ocnitei and Boldesti. The curve is much smoother and the decline more regular from non-paraffinous wells normally produced, than those from paraffin wells. (Graphs of curves from Gura Ocnitei Wells Nos. 4 and 15 handed around.)

Well No. 4 Gura Ocnitei came in on June 26th, 1930, and flowed normally through 9-mm. to 13-mm. beans until the first part of August, when we were obliged to shut it in for technical reasons. It was not opened again until the potential tests in September, when it produced just over 30 litre cars through an 18-mm. bean. The well was shut in following the potential test and was not opened again until December 5th. We expected it would produce normally, but instead of so doing the gas-oil ratio increased very markedly with beans of approximately the same size as were used on the first test. On decreasing the size of the bean we found the gas-oil ratio increased. In an effort to stablilize the production we slowly increased the bean, causing augmented gas production, an increase in production and a decrease in gas-oil ratio. We were faced with the predicament of either shutting in the well to conserve the gas or produce with high ratio. We decided on the former alternative. The curve shows the effect of closing in the well, opening it up and finally closing it in. In this case the expanding gas cap forced the oil down structure into the adjacent wells which were producing during the time the well was closed.

Well No. 13 is located some distance down the dip from No. 4 and slightly lower on the structure that No. 10 Unirea. In this well the effect of closing it in and opening it up again is not marked. This is probably due to the fact that the gas cap has not expanded very far down the structure.

Were this performance to take place in the life of the well the chances are it would show up in some way as in well No. 4.

At present well No. 13 is producing at the rate of about 56 kg. cars/day with a ratio of 1,545 c. ft./brl., bean 19-mm. This compares with a maximum production on December 6th (through a 21-mm. bean) of 86·5 kg. cars. In No. 13 the decline is fairly normal comparing more with the decline in type "C" well, a fairly flat decline.

You will notice in the specifications of the producing string that the perforations in the liner and the spacing of the holes in the liner are approximately the same as in No. 4, also the crude analysis is approximately the same.

Well No. 165 Moreni (a third Meotic sand well brought into production on January 30th), produced with varying changes in bean diameters until September when, following the potential test, it was closed in on account of the fact that the gas-oil ratio was showing a too marked increase, and to the fact that we did not wish to produce large quantities of paraffin oil at the time. The decline is fairly regular until January of this year.

The normal decline of third sand wells is typified by Astra Romana wells Nos. 304 and 314. These curves are fairly flat, probably not more than 2° per month, with the gas-oil ratios remaining fairly constant. When well No. 165 R.A. was shut in at the end of October 1930 and later was opened up during the first part of November a difference in production of 4½ litre cars was noted. When it was closed in it was producing at the rate of 20½ litre cars per day, and when opened up showed a decrease to 16½ litre cars. We have never been able to bring it back to the former production.

Decrease in bean size means decrease in ultimate production and rapid expansion of the gas cap with resultant down-dip drive of the crude.

Wells Nos. 13 and 15 R.A. Boldesti. It will be noticed that the decline curve for Well No. 13 shows no continuity, this is due to operating difficulties—pipeline troubles mostly (paraffining) and to paraffinous crude oil requirements of the refinery. In any event the curve shows that after decrease of flow bean diameters, followed by increases, there is a very marked decrease in production. With a large flow bean a certain production is obtained; having decreased the diameter of the bean and later increased it, the original production is not regained. This apparent loss of

production is not entirely due to the fact that there is gas expansion. In this particular case there was some trouble with one of the Astra Romana wells adjoining (No. 11) which had a bad blow out, causing us to close in our well, which subsequently never regained its initial production. In any event, if you will consider the curve from December 4 to the end of March, and draw a normal line through the various high points, there will be a difference between the curve so drawn and that shown in the sketch. The area between the two represents the amount of crude lost. In all probability this will not be crude which can be recovered subsequently, therefore it is definitely lost.

At Well No. 13 Boldesti a similar condition obtains; the well has been produced normally for a certain period of time, shut in, opened up again, flow bean decreased, opened up again and shut in and finally produced normally. The fluctuations are quite marked, and in all probability there has been some deviation of oil flow to other wells, thus preventing possible future recovery. Gas-oil ratios are fairly high. It has been noted at this well that when the flow bean has been increased in size there is a very marked increase in gas produced with consequent increase in gas-oil ratio. In order to prevent gas wastage, with consequent waste of lifting energy, the well is beaned down to smaller diameter at present.

These examples serve to illustrate the dangerous practice of beaning-in wells, increasing the bean, beaning them back again —particularly on paraffinous producers. It is much better to bring in a well normally, produce it on a bean of certain size, rather than to increase the bean and then to decrease it.

Mr. Masterton said that it seems a pity that the people who decide on measures to be taken in these matters are nearly all commercial men and have probably never seen a curve. It appears that shutting in generally is not a very good thing. He thought that, generally speaking, we attack the over-production position from the wrong end, and that the best thing is to restrict drilling rather than to restrict production after we have drilled for the oil. If everybody realized the harm done by shutting in we would work out some scheme for restricting drilling.

Mr. Elias (in closing the discussion) said that he was sorry that more theories had not been offered as to why wells behave as they do when closed in. One theory as to what happens to the oil probably lost in the areas shown by the diagrams is that the loss is probably due to thief sands. As none have contested that, it is probably the accepted theory. The whole question of restriction as it affects pinched-in or shut-in wells is very important.

As long as restriction is based on potential tests we shall have this situation of having to drill and then lose production by shutting the wells in. If we have to restrict again we, as technical men, must hope that some method of basing production will be developed other than on potential runs.

He drew attention to a point in the curve of Romano Americana Well No. 4, Gura Ocnitei, which shows a condition which he had found in a number of wells. This well, in December, was beaned up and the production rapidly rose, but in spite of further beaning up production declined fairly rapidly and the gas-oil ratio went up. He had not any very definite idea why it happened, and the only reason he could think of is that when the well is closed in the pressure builds up in the vicinity of the well and the oil migrates towards the area of low pressure. Then, as soon as the slight flush of oil which is in the immediate vicinity of the well has been produced, the oil has to be brought from a greater distance and requires more gas to overcome resistance of sand, so the ratio comes up and the production drops. It is very well illustrated in the diagram of No. 4.

Mr. Crooks said that probably the gas was by-passing the oil through the sand and not forcing it into the well.

The Removal of Weak Organic Acids from Oils by Treatment with Caustic Alkali.*

By P. Meyer, B.Sc., A.I.C. (Associate Member).

Weakly acidic bodies, such as mercaptans, phenols, etc., are frequently present in oils as impurities, and may be removed by treatment with aqueous alkali, such as sodium hydroxide solution.

On batch treatment removal is often only partial. A quantity of free acid remains in the oil layer, in equilibrium with the alkaline layer, and is not removable by further agitation. The amount thus remaining is dependent upon the amount originally present, the acidity of the substance, the amount and concentration of the soda used, the temperature, and other factors.

From the well-known fact that concentrated aqueous solutions, such as sodium mercaptides, hydrolyse on dilution, liberating the free acid, it might be thought that a given weight of alkali would be more effective if used at high concentration than if well diluted. In actual practice, however, the acid body present in an oil may be present only at great dilution; and it is shown below that in such a case the more dilute soda may be much more effective.

The equilibrium obtained is the resultant of a large number of reversible reactions occurring simultaneously, and is governed by mass-action laws. In removing mercaptans, for instance, from petroleum fractions, the aqueous layer will contain

Free mercaptan in solution [HSR]
Undissociated sodium mercaptide [NaSR]
Mercaptide ion [SR]

The equilibrium reactions concerned are as follows:—

(1). The mercaptan tends to distribute itself between the oil and the aqueous layer by simple solution.

$$[\text{HSR oil}] \rightleftharpoons [\text{HSR aqueous layer}]$$

$$\frac{[\text{HSR oil}]}{[\text{HSR aqu}]} = C_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

(2). Sodium mercaptide is formed.

$$[\text{NaOH}] + [\text{HSRaqu}] \rightleftharpoons [\text{NaSR}] + [\text{H}_2\text{O}]$$

$$\frac{[\text{NaOH}]\,[\text{HSR aqu}]}{[\text{NaSR}]\,[\text{H}_2\text{O}]} = C_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

* Paper received August 16th 1931.

(3). The free mercaptan in the aqueous layer is partially ionised.

$$[HSR\ aqu] \rightleftharpoons [H]^1 + [SR]^1$$

$$\frac{[HSR\ aqu]}{[H]^1\ [SR]^1} = C_3 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

(4). The sodium hydroxide present is partially ionised.

$$[NaOH] \rightleftharpoons [Na]^1 + [OH]^1$$

$$\frac{[NaOH]}{[Na]^1\ [OH]^1} = C_4 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

(5). The sodium mercaptide is partially ionised.

$$[NaSR] \rightleftharpoons [Na]^1 + [SR]^1$$

$$\frac{[NaSR]}{[Na]^1\ [SR]^1} = C_5 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

(6). The hydrogen and hydroxyl ions are in equilibrium.

$$\frac{[H]^1\ [OH]^1}{[H_2O]} = C_6 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Now in the case of concentrated sodium mercaptide solutions, conditions are represented mainly by (2) above. The effect of dilution is mainly hydrolytic, and results in the liberation of free mercaptan.

In the case of petroleum spirits, however, only small amounts of mercaptan are normally present (equivalent to say 0·2 per cent. mercaptan sulphur), and the soda solution obtained is only partially "spent," consisting of a dilute solution of sodium mercaptide with a large excess of free alkali. In such a case ionic dissociation as distinct from hydrolytic dissociation is the major factor.

Combining equations 1, 2, 4 and 5, we find that

$$[SR]^1 = \frac{C_4\ [HSR\ oil]\ [OH]^1}{C_1C_2C_5\ [H_2O]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Similarly from equations 1, 3, 6,

$$[SR]^1 = \frac{[HSR\ oil]\ [OH]^1}{C_1C_3C_6\ [H_2O]} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8)$$

Now the mercaptan removed by the soda is present in three forms:—free [HSR] aqu, [NaSR] and [SR].[1] Distilled water alone removes a negligibly small quantity of mercaptans from oil solution, as might be expected since the pure compounds (with the exception of the lighter members) are practically insoluble in water, and would be correspondingly less soluble when already greatly diluted with oil. Hence the [HSR] aqu term expressed in grams per ml. is

negligibly small. Moveover at the dilution considered most of the sodium mercaptide present would be ionised. It follows, therefore, that the mercaptan, or mercaptan radicle, removed by the soda, is removed mainly as mercaptan ion [SR].[1]

From equations 7, 8 above, it is seen that other factors being constant the $[SR]^1$ term is directly proportional to the $[OH]^1$ term.

A solution containing 100 g. NaOH per litre is about 50 per cent. ionised at ordinary temperatures; while a solution of one-tenth this strength is about 95 per cent. ionised. Thus, for a given weight of NaOH, the dilute solution contains nearly twice as many [OH] ions as the stronger solution. Meanwhile the molal H_2O concentration is not much increased, scarcely affecting the hydrolytic dissociation by equation 2. From equations 7, 8, therefore, we should expect that for a given equilibrium concentration of mercaptan in the oil layer, a gram of NaOH in 1 per cent. solution should remove twice as much mercaptan as a gram of NaOH in 10 per cent. solution.

Experimental confirmation of this fact was obtained in the following manner. In a typical experiment, 0·3 ml. normal propyl mercaptan were added to 50 ml. of refined petroleum spirit. The solution was shaken with 5·2 ml. of 10 per cent. sodium hydroxide solution. It was found by trial that equilibrium was attained after three minutes' vigorous hand shaking. A blanket of inert hydrocarbon gas in the vapour space of the shaking funnel was found necessary in order to minimise atmospheric oxidation of the mercaptan. The soda wash, plus water rinsings, was then run into an excess of acidified iodine solution, and the mercaptan removed determined by measuring the iodine absorption.

$$2\,NaSR + I_2 = 2\,NaI + R_2S_2$$

Several such soda washes were given, the iodine absorptions found being given below:—

	N/10 Iodine absorbed by Wash. ml.	Total removed. (expressed as ml. N/10 Iodine).
First Wash.. ..	21.45 ..	21.45
Second „ ..	7.40 ..	28.85
Third „ ..	2.70 ..	31.55
Fourth „ ..	0.95 ..	32.50
Fifth Wash ..	0.40 ..	32.90

In Fig. 1, the total removed is plotted against the number of washes. It will be seen that the dotted line, LM, representing the mercaptan originally present in the spirit, is asymptotic to this curve; theoretically, removal is only complete after an infinite number of washes.

It may be observed from the results that the equilibrium amount of mercaptan plus mercaptide in the aqueous layer is in linear relationship to the amount of mercaptan remaining in the oil layer.

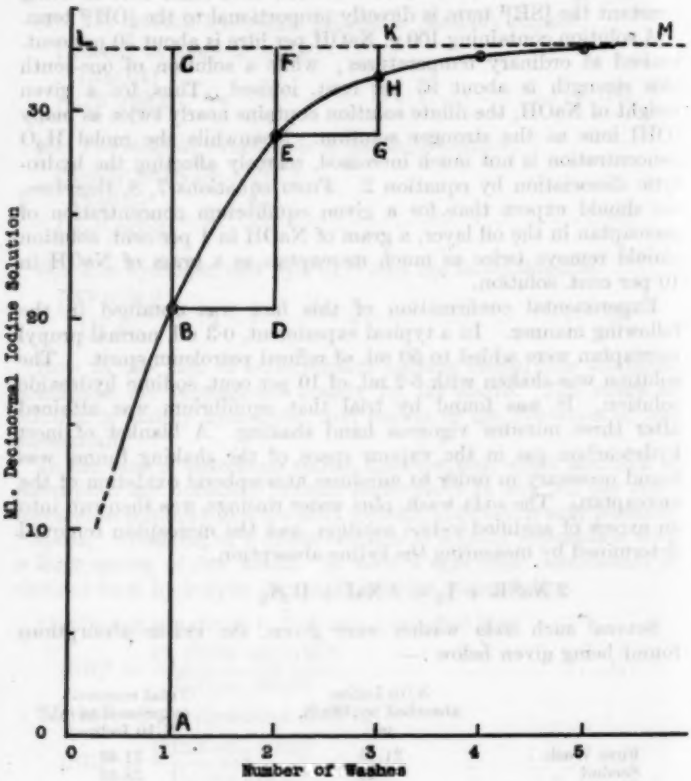


FIG. 1.

Thus :—

AB/BC	=	21.45/11.55	=	1.85
DE/EF	=	7.40/4.15	=	1.78
GH/HK	=	2.70/1.45	=	1.86
			Average	1.83

This constant ratio is in agreement with equations 7, 8, indicating that, at the dilution considered, the mercaptan in the soda layer is present chiefly as SR ions.

The ratio

$$\frac{\text{Concentration of mercaptan plus mercaptide in aqueous layer}}{\text{Concentration of mercaptan in oil layer}} = \frac{[HSR]\ aqu + [NaSR] + [SR]^1}{[HSR]\ oil}$$

may be called the overall distribution co-efficient or partition co-efficient. When the terms [HSR]aqu and [NaSR] are small, in comparison with the $[SR]^1$ term, this ratio approximates to

$$\frac{[SR]^1}{[HSR\ oil]}$$

The value of this ratio may be found from the ratios AB/BC, DE/EF, GH/HK = 1·83. Since 50 ml. oil and 5·2 ml. aqueous layer are present, the overall distribution co-efficient is

$$\frac{50}{5{\cdot}2}\ 1{\cdot}83 = 17{\cdot}6$$

This value may, however, be found with greater accuracy by calculation. Assuming that the value of the distribution co-efficient is constant, then the curve OBEH is of the type

$$y = k\ (1 - a^x)$$

where y = total removed by x washes
k = amount originally present in the oil
a = constant.

The distribution co-efficient may be calculated from "a" as follows:—

$$\text{Distribution co-efficient} = \frac{50}{5{\cdot}2}\ \frac{1-a}{a}.$$

For the data quoted, k = 33·0, and a = 0·3505. The observed values of y are within experimental error of the calculated values:—

	Value of y. Observed.	Calculated.
First Wash	21.45	21.45
Second ,, ...	28·85	28·95
Third ,, ...	31.55	31.60
Fourth ,, ...	32.50	32.50
Fifth ,, ...	32.90	32.85

and the value of the partition co-efficient is

$$\frac{50}{5{\cdot}2}\ \frac{1-0{\cdot}3505}{0{\cdot}3505} = 17{\cdot}8$$

Similar determinations were carried out with other soda strengths and with other pure mercaptans. The results are tabulated below :—

Mercaptan.	Soda solution (Gms. NaOH/ 100 ml.).	Overall Distribution Co-efficient.
N-Propyl	10.0	17.8
	5.0	13.5
	1.0	3.5
N-Butyl	10.0	4.1
	5.0	3.2
	0.5	0.47
Iso-Amyl	10.0	1.1
	1.0	0.25

(*Note.*—These results are relative to the molecular volume of the petroleum spirit employed, and to the temperature of the experiments, which latter was 100° F. approximately.)

It will be noted that the overall distribution co-efficients for 1 per cent. soda are about one-fifth those for 10 per cent. soda. Since, however, for a given weight of soda, ten volumes of the weaker soda are available for every volume of strong soda, it follows that about twice as much mercaptan is removable with the weaker soda. This is in satisfactory confirmation of the theoretical investigation previously made.

Although batch washing effects only partial removal of the mercaptans, complete removal is theoretically possible by counter-current treatment.

For instance, to remove all the propyl mercaptan present in an oil, the oil might be extracted in continuous counter-current manner in a packed column washer (Fig. 2) of suitable height, with $1/17{\cdot}8 = 0{\cdot}0562$ volumes of 10 per cent. soda, or with $1/3{\cdot}5 = 0{\cdot}286$ volumes 1 per cent. soda, only about half the weight of soda being necessary in the latter case.

The double efficiency is not, however, realisable by batch washing. Bulk agitation of 100 gallons spirit with 5·62 gallons 10 per cent. soda would effect 50 per cent. removal of propyl mercaptan; while on diluting this same weight of soda to 56·2 gallons, the removal would be 67 per cent.

Where compounds of low acidity have to be removed, however, it is generally not possible to secure satisfactory equilibrium in the packed column type of washer. A series of mixing pumps and settling tanks may, however, be used to simulate counter-current extraction, as shown in Fig. 3. Assuming equilibrium in each mixing pump, and supplying just sufficient soda to remove all of a given compound by theoretical counter-current extraction, the efficiency of removal will actually be $n/n+1$, where n is the number of pump stages. Thus four such stages will effect 80 per cent.

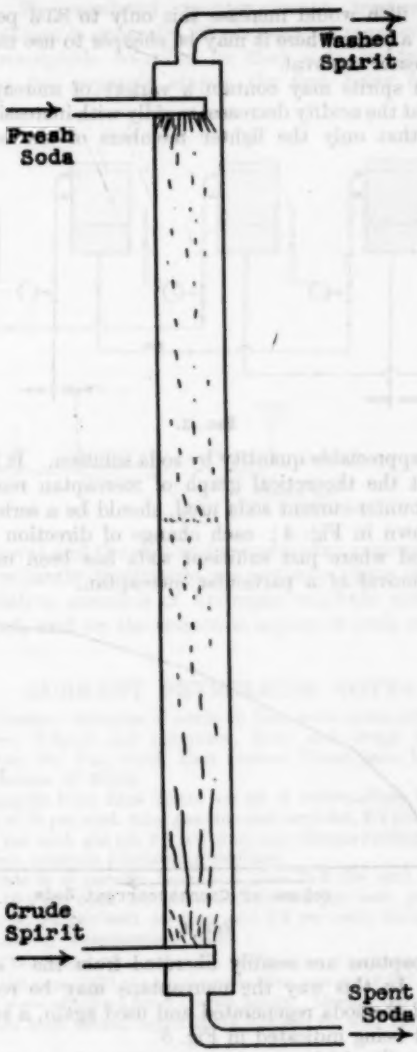


FIG. 2.

removal; a fifth would increase this only to 83·3 per cent., and there comes a point where it may be cheaper to use more chemical to secure greater removal.

Petroleum spirits may contain a variety of mercaptans. It is apparent that the acidity decreases rapidly with increasing molecular weight, so that only the lighter members of the series can be

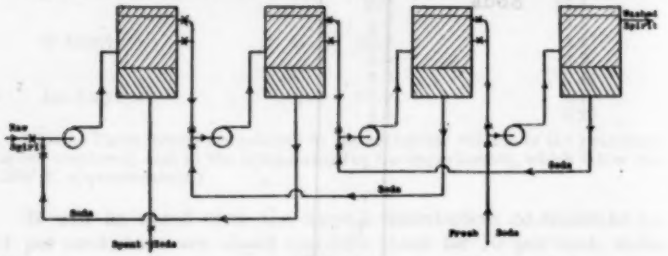


FIG. 3.

removed in appreciable quantity by soda solution. It is interesting to note that the theoretical graph of mercaptan removal versus volume of counter-current soda used, should be a series of straight lines, as shown in Fig. 4; each change of direction indicating a point reached where just sufficient soda has been used to effect complete removal of a particular mercaptan.

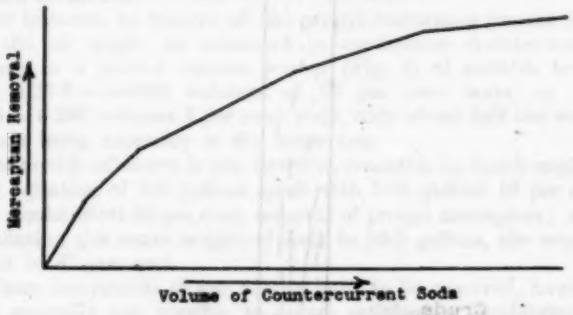


FIG. 4.

Free mercaptans are readily liberated from the "spent" soda by boiling. In this way the mercaptans may be recovered and isolated, and the soda regenerated and used again, a suitable plant arrangement being indicated in Fig. 5.

Generally, oils which contain mercaptans also contain hydrogen sulphide. This substance is appreciably more acidic than the

mercaptans. By regulated counter-current treatment sodium hydroxide solution is generally 80 per cent. or more convertible to sodium hydrosulphide solution, so that soda treatment is best considered as two separate stages, the first being for hydrogen

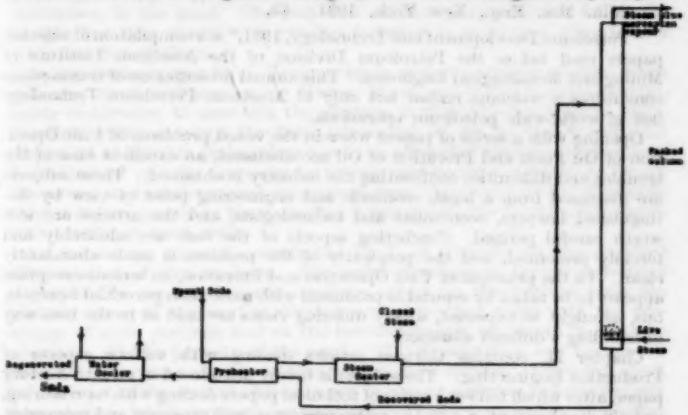


FIG. 5.

sulphide removal and the second for mercaptan removal. Whether or not two separate treatments are actually given, is dependent upon the relative amounts of hydrogen sulphide and mercaptan to be removed, and on the economic aspect of soda recovery.

CURRENT PETROLEUM NOTES.

East Texas Crudes.—Samples of crude oil from wells in the newly developed fields of Joiner, Kilgore and Longview, Rusk and Gregg Counties, East Texas, and from the Van Field, East Central Texas, have been examined by the U.S. Bureau of Mines.

The four samples from East Texas are all of intermediate base and gave average yields of 36 per cent. total gasoline and naphtha, 9·6 per cent. kerosine distillate, 15·1 per cent. gas oil, 9·7 per cent. non-viscous lubricating distillate, and 6·2 per cent. medium lubricating distillate.

The Van crude is of paraffin base, and gave 24·6 per cent. total gasoline and naphtha, 16·1 per cent. kerosine distillate, 8·2 per cent. gas oil, 11·4 per cent. non-viscous, 7·2 per cent. medium and 1·4 per cent. viscous lubricating distillate.—*Report of Investigations* 3130.

Trinidad.—The official figures for the production of petroleum in Trinidad show that for the year 1930 the total production was 9,418,907 brls., of which 5,260,366 brls. were obtained from Crown lands. During the year 163 wells were drilled, the total drilled depth being 372,530 ft., and 121 of these wells obtained oil.

Two Ordinances were passed during the year:—(1) The Oilfields Fires Control Ordinance, 1930; (2) Water Control (Oil-bearing Sands) Ordinance 1930.

REVIEW.

Petroleum Development and Technology, 1931. Trans. Amer. Inst. Min. Met. Eng., New York, 1931. $5.

"Petroleum Development and Technology, 1931," is a compilation of selected papers read before the Petroleum Division of the American Institute of Mining and Metallurgical Engineers. This annual presentation of transactions constitutes a welcome review not only of American Petroleum Technology but of world-wide petroleum operations.

Opening with a series of papers wherein the vexed problems of Unit Operation of Oil Pools and Proration of Oil are discussed, an excellent idea of the troubles and difficulties confronting the industry is obtained. These subjects are discussed from a legal, economic and engineering point of view by distinguished lawyers, economists and technologists, and the articles are well worth careful perusal. Conflicting aspects of the case are admirably and forcibly presented, and the perplexity of the problem is made abundantly clear. To the principle of Unit Operation and Proration, no serious exception appears to be taken by reputable producers with more than parochial interests, but, as might be expected, widely differing views are held as to the best way of handling a difficult situation.

Chapter II. contains thirteen articles dealing with various aspects of Production Engineering. The subject is briefly introduced in an introductory paper, after which follows a series of technical papers dealing with repressuring, orderly development of oilfields, water problems, well pressures and recoveries, flowing problems, mud questions and casing programmes. An increasing recognition of the value of controlled edge water for increasing the recoveries of oil is in line with the ideas of many practical operators. As a result of numerous observations, doubts are raised in an article by S. F. Shaw on the correctness of the theory that lowered viscosity results in a lower gas-oil ratio and a higher ultimate recovery of oil. The writer very ably argues that there are probably other factors which outweigh the influence of reduced viscosity.

Bottom-hole pressures and bottom-hole beans are the subject of two interesting articles. The use of the latter has always been an intriguing possibility, but the difficulty of adjusting or repairing a fitting at the base of the well has, until recently, been regarded as a serious objection. Types have now been invented which are said to remove many obstacles, but it is agreed that too little data has yet been collected to enable satisfactory conclusions being reached.

The flow velocities of gas/oil mixtures is the subject of a paper, and two articles dealing with rotary muds serve to show how much has yet to be learnt about the behaviour of mud under different conditions.

Chapter III., under the heading of "Engineering Research," contains seven articles dealing with the solubility of natural gas in crude oil; principles governing the length and diameter of tubing in oil wells to secure continuous flow; slippage in flow through vertical pipes; interpretation of core analyses; permeability studies of Pennsylvanian oil sands; study of production curve of a Texas 8500 ft. sand, and two papers on the Microscopic Study of California Oil Emulsions.

The first papers serve to emphasize the fact that there is yet much to learn about the state and importance of gas dissolved in crude oil as it exists in the earth. Solubility graphs are given for a number of hydrocarbon gases at various pressures as well as the shrinkage volumes as a result of the release

of gas at different pressures. The latter are cause for some surprise, and in the debate which followed the reading of the paper, the relative usefulness of the various gases as propulsion or transportation agents in the sands was discussed. It is submitted that only those gases which remained gaseous at the prevailing temperatures and pressures in the earth could influence movements in the sand. The fact that solution graphs do not follow the straight line they should with pressure increase is proof that other factors enter into the problem.

An interesting paper by J. Versluys deals with the subject of flows when wells are tubed, and another by Messrs. Moore and Wilde describes experiments undertaken to ascertain the slippage in flow through vertical pipes. The first writer develops the foam (dispersion of gas in liquid) and mist (dispersion of liquid in gas) explanation in an attractive manner, and discusses the subject of velocity necessary to entrain various sized droplets of liquid. Theoretical and mathematical conclusions were questioned in the discussion which followed, partly on the score that it was impossible to reproduce conditions existing in deep wells.

An instructive paper is contributed by L. S. Panyity on the practical interpretation of core analyses. The writer develops an ingenious method of graphically representing core analyses where on the vertical scale the total thickness of the sand is divided into convenient units with the percentage of shale partings, and on the horizontal scale are shown in separate columns: (1) The porosity of the sand; (2) Oil saturation and barrels per acre; (3) Percentage of grain passing various sized screens. From this chart the condition of the sand at all depths can be seen at a glance, and particularly those changes which promote permeability and therefore higher absorption at definite pressures. The author submits that screen analyses afford the most reliable basis for calculations when considering schemes for repressuring by water flood, air or gas, and he gives an analysis of what he regards as the ideal sand in the Bradford Field of Pa., which takes 1 to 1¼ brls. of water per ft. of sand a day at 1500 ft. in the holes being drilled.

Another paper by Fattke and Copeland also discusses the relationship of porosity and permeability in a practical manner.

Two profusely illustrated papers on Oilfield Emulsions are presented by Mahmood Abozeid and Harman Fisher. Without specialised knowledge, difficulty may be found in interpreting the photo-micrographs. The last named author specifically refers to the extreme lack of knowledge concerning the formation and behaviour of colloids.

Chapter IV. is devoted to the subject of Oil Production, and contains a series of articles by recognised authorities in most oil-producing countries. The U.S.A. domestic fields are treated in ten articles, the foreign in thirteen, and both series give an excellent account of recent developments and the problems related thereto. Only the briefest reference can be made to a few of the more striking statements of international interest. When dealing with Oklahoma it is stated that the Corporation Commission of the State placed the potential yield of the Oklahoma City field at 6,411,000 brls. a day in March, 1930. Such a figure could not find general acceptance with oil technologists, especially as the field had only yielded 43,000,000 up to the end of 1930, little more than a week's potential. The writer of the article estimates that producers invested $132,000,000 in the field, exclusive of Administration charges, damages, taxes, lease equipment, interest and operating expenses, of which $84,000,000 remained to be recovered at the end of 1930.

Concerning the manufacture of carbon black, it is said that in Louisiana only 40 per cent. of the produced gas was used in this way compared with

80 per cent. in 1924, but it is also affirmed that 24 plants in the Texas Panhandle produced 110,000 tons from 120,000,000,000 cu. ft. of gas and that local storage had increased to 79,000 tons.

When dealing with the Gulf Coast operations, the statement is made that in 1930 geophysical work led to no definite discoveries of new salt domes, although a number of seismic and gravity anomalies were noted. In consequence of the probable discovery of all shallow domes, very considerable money has been vainly spent in deep tests to prove geophysical prospects.

The Hobbs field of New Mexico came into the limelight in 1930, and was a menace to price stability till severely prorated. At the end of the year it is claimed that 137 wells had a potential yield of 1,084,000 brls. and some 10,000 acres had been proved. In California the two outstanding events of the year, to which reference is made, were the striking of 40° Bé. oil below the gas zone of Kettleman Hills and the discovery of 46° Bé. deep oil at Belridge. The potential of the first-named field is very large, the latter was only newly discovered. A production graph shows that production at the end of 1930 constituted only 50 per cent. of the potential of the State which gave 228,000,000 brls. in the year.

Under foreign fields much valuable information will be found in the various papers, but the one that will be read with most interest by oil producers is that dealing with Russia. B. B. Zavoico not only describes developments in hand, but gives much valuable information regarding the objects and intentions of the Soviet Government. Fantastic forecasts of production have been made which, if partially realised, are likely to embarrass oil operators in all countries. Rich as the Baku oilfields are, it seems improbable that they will respond to the extent of yielding the estimated quantity of 146,000,000 brls. in 1933 owing to the extent of past depletion. Amongst the interesting facts disclosed are anticipated productions of 68,000,000 brls. in 1933 for the new and old Grosny field, 28,400,000 brls. for the Maikop field, 14,500,000 brls. for the newly discovered Benoi Grosny field and 20,300,000 brls. for the Emba field. As the present output of Maikop is 3,000,000 brls. and Emba 2,460,000 brls., considerable faith is held regarding the future of these areas.

The author concludes his paper with the remark that it is doubtful whether the Soviet Government will be allowed to continue its market-breaking policy without forcing other countries to place an embargo on their products.

The articles on Economics in Chapter V. by distinguished writers will well repay their study. The extent to which gasoline determines the profits of the industry is emphasised by most writers, and one goes so far as to say that we must realise that the oil industry to-day is essentially the gasoline industry, yielding as it did in U.S.A. in 1930 42·5 per cent. of the volume and 60·2 per cent. of the value of crude oil. Another writer in arguing in favour of artificial methods of restricting output denies the existence of a law of supply and demand, and submits that this figure of speech is merely a formula. Proration is described as a co-operative enterprise between the State and the industry; and an embargo on imports in U.S.A. is pleaded on the score of expediency, although it cannot be justified by the logic of economics. Joseph E. Pogue in an article stresses the necessity of reducing the potential before a price recovery can be expected.

The whole work is a highly creditable compilation of valuable data of use to all connected with the oil production and marketing.

The book can be heartily commended, and it is sure to find an honoured place on the bookshelves of all interested in Oil Technology.

A. Beeby Thompson.